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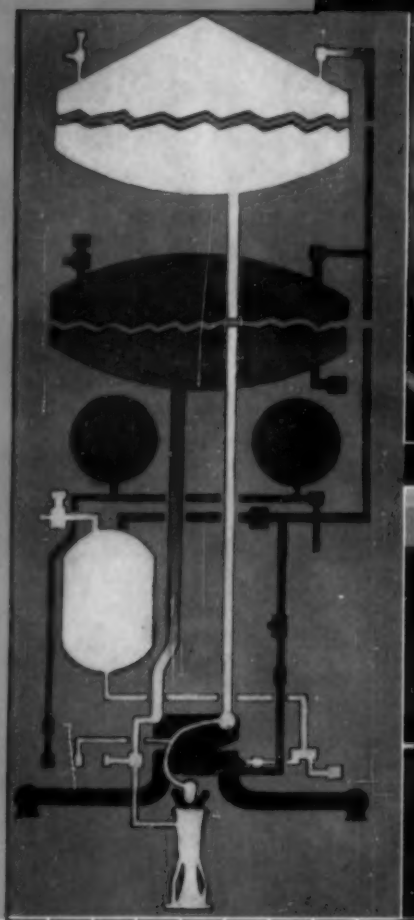
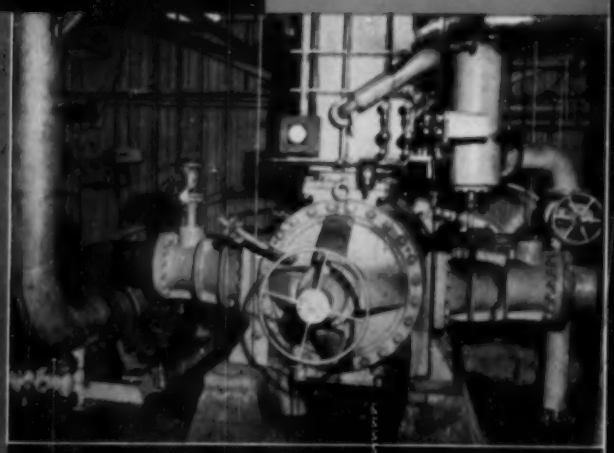
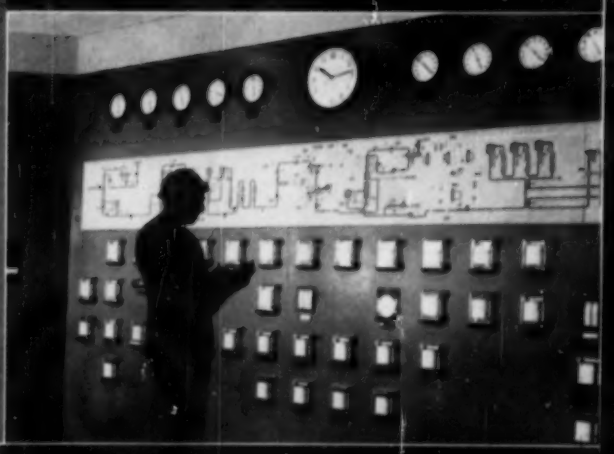
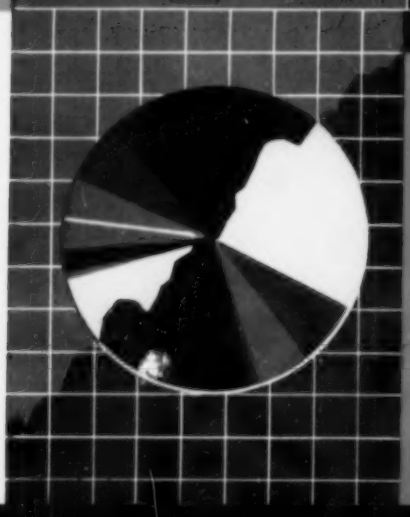
Automatic control of process plants is upsetting time-honored bases for estimating labor costs, which are soaring with demands for higher skills.

CHLOR-ALKALI TRENDS
Chlorine-caustic enigma: how practical will it be to produce one without the other?









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VULCAN
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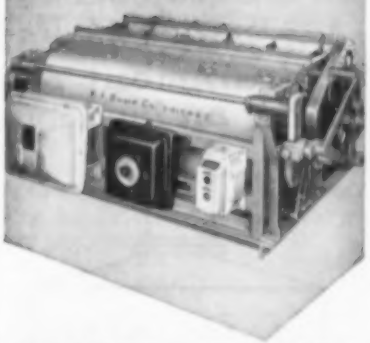

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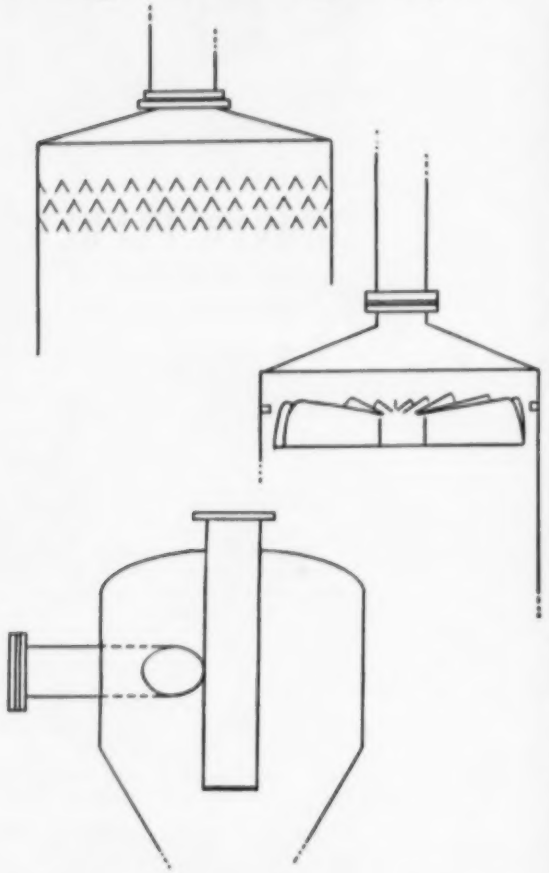

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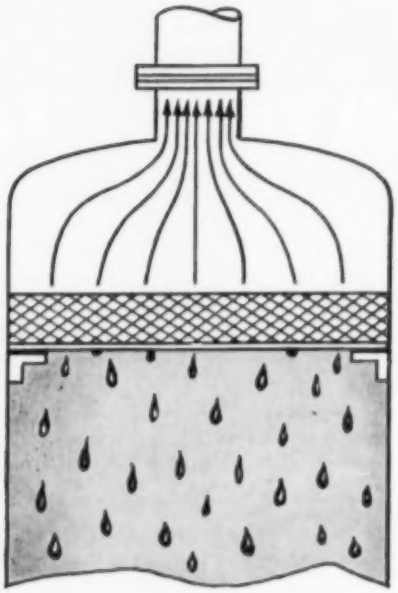

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THE CHEMICAL ENGINEER AND POLITICS

T. R. McKeldin

Governor of the Free State of Maryland

At the beginning of the modern world, some three hundred and fifty years ago, to speak of a man as "a scholar" was to describe him fairly definitely. It meant such a man as Sir Francis Bacon, who undertook, seriously, to write a book summarizing human knowledge—everything that mankind had learned.

It is true that Bacon never finished the book. It was still incomplete when he died six years later. But the interesting point is that in 1620 nobody assumed that Bacon must be insane. It was regarded as quite possible for one man to learn all that was known, and to set it down in the course of a single lifetime.

Today, if any man were to announce seriously that he proposed to write a book containing all knowledge, our first impulse would be to begin making quiet preparations to put him in a padded cell, for no sane man would think of such a thing. So today to call a man a scholar is anything but definite. Is he artist, scientist, philosopher, jurisconsult or theologian? If he is a scientist, is he a natural scientist or a social scientist? Knowledge is divided into compartments and each compartment is enough, and more than enough, to absorb the energies of a lifetime.

That, at least, was the trend from Bacon's time up to about fifty years ago. Specialization appeared to be the only approach to man's mastery of his environment. But near the beginning of this century—in 1905 to be exact—a loud voice was heard flatly denying this theory and proclaiming that nothing can be known of itself alone, that an important part, perhaps the most important part, of knowledge of any one thing is its relation to other things. Einstein's Theory of Relativity demolished the whole structure, not merely of physics alone, but of the system of education. The most distinguished scientists in the world had to go back and learn their science all over again.

Let me hastily disavow any intention to expound Einstein. I am a lawyer, not a physicist, and it is far beyond my ability to understand, much less to explain, the details of his theory. But precisely because I am not concerned with the mathematics involved, I may have a clearer view of the wide implications of relativity than can be obtained by a man struggling with the enormously difficult details of its application. For instance, although I am neither a chemist nor a physicist, I know that the boundary line between those two sciences has grown extremely dim, and that at certain points both merge imperceptibly into biology. The compartments of knowledge turn out to be mere figures of speech, rather than divisions separated by water-tight bulkheads.

You cannot know chemical engineering without knowing a great deal of mathematics and having a pretty good grasp of physics. Geology, geography, and climate all have their effects on chemical engineering, especially in the planning stage, and I have no doubt that you encounter problems in some of the biological sciences.

To this engineers will agree as a matter of course, but here is an assertion with which you may not agree at all without considerable argument. It is this: you cannot be a chemical engineer on the highest level of competence without some knowledge of politics.

Let me define my terms, taking first "the highest level of competence."

I will readily admit that a man can build an efficient oil refinery without having the slightest idea whether the head of the state in which he builds is a president, a dictator, a king, or a sultan. But I do not admit that building an

(Continued on page 10)

From an address before A.I.Ch.E. banquet meeting, Baltimore, Maryland.

DESIGNS FOR TOMORROW'S DESIGNERS

Walter E. Lobo *

I should like to have the student design engineer given a little practice in plant and reactor design, as well as in process development. Such courses would stimulate the search for alternative methods and would give him something to tie to his more fundamental studies. I insist that he be given a sound and thorough course in Engineering Economics. The phrases, "for the least money," "at the lowest cost," "with the best return," or "the quickest payout" will be with our designer throughout his career. I want him to learn early to apply cost consciousness to all his engineering work.

The design chemical engineer will be confronted with lack of knowledge, time after time. He will wish for more laboratory data, more analytical work, more pilot plant operation before making his design final, and yet he will be unable to delay his judgment. He will have to make a decision on the basis of what he knows then and there. To prepare him for this early in his professional career, why not teach him all we can about *decision making*. Give him all the tools which will help him to weigh alternatives and to make the best possible choice. Why should we wait until the engineer is approaching managership and then rush him through a specialized training program?

The design chemical engineer is a salesman. He creates a new process, or puts together a new design. But to put it to use he must sell the fruit of his brain. He must sell it to his boss, to his company, or to his customer. Has he been properly trained to put his ideas across? Isn't this another field [the field of communication and human relations] in which we have an opportunity to give our chemical engineering graduate, tomorrow's designer, some help in school?

As a salesman of ideas, the chemical engineer has to deal with people—all kinds of people—technical and nontechnical, subordinates, associates, superiors, salesmen, and customers. Therefore, he must understand people, why they act as they do, and how best to get along with them. So why not teach him applied psychology and the fundamentals of human relations? He will get along better at the university, if you do. He will be a better graduate; he will get a better job; he will be a better engineer; a better person.

*** The above remarks are taken from an address by Mr. Lobo, a director of A.I.Ch.E. and a chemical engineering consultant in New York City, before the ACS Div. of Ind. & Eng. Chem. at Atlantic City.**

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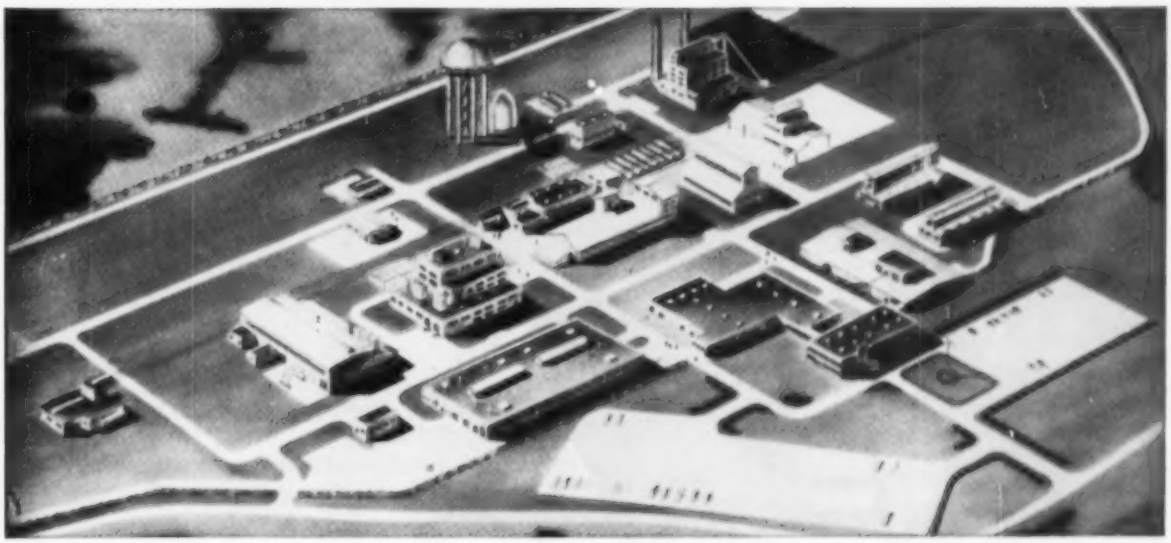

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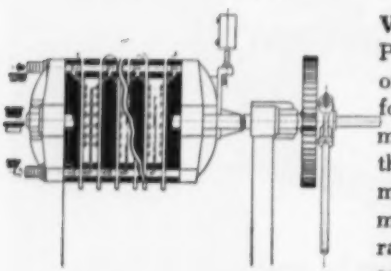

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(*Continued from page 6*)

oil refinery, or any other installation, represents the highest level of engineering competence. A higher level is that occupied by the man who directs, not any number of construction jobs, but the policy of an industry and the trend of a profession.

Then let me define my second term, "politics." It doesn't mean getting elected to office, or getting some friend elected. It means the conduct of public affairs. It includes everything that can reasonably be regarded as contributing to the general welfare.

Why does the profession of chemical engineering exist? Obviously, to better the condition of the world, to make the lives of the people easier, more productive, more satisfactory. But there are ten thousand things working to the same end and unless each fits in with the others they will pull against each other. It is a problem of finding the proper relation, and unless the chemical engineer knows the relation of his work to other social and economic forces he doesn't know all there is to know, or all he ought to know, about his job.

But you can't find out much about social and economic relations from a book. The way to find out is to associate with the people, to find out what their problems are and what they think about them; and the best way to find out about a problem is to take a hand in the effort to solve it. This is political activity in the broad sense.

It goes without saying that such activity makes you a better citizen; but I submit that the man who is becoming a better citizen is at the same time becoming a better chemical engineer. He is extending his intellectual limits, and the man who is doing that is becoming steadily more competent to practice any profession.

It seems to me that this applies with special force to the younger men. In the first place, it is when a man is just getting well established and is on his way up that he usually drives hardest and therefore is most likely to lose sight of broad relations in his concentration on the narrow problem in hand. In the second place, when a man has grown older and is approaching the top, he has more and more need of the broad view, and finds it harder and harder to acquire. It is easy only if he has established the habit of looking beyond his professional limits, and from his early days has studied the social, economic, and political relations of his work.

In the modern world no man can encompass all knowledge, but every

(*Continued on page 30*)

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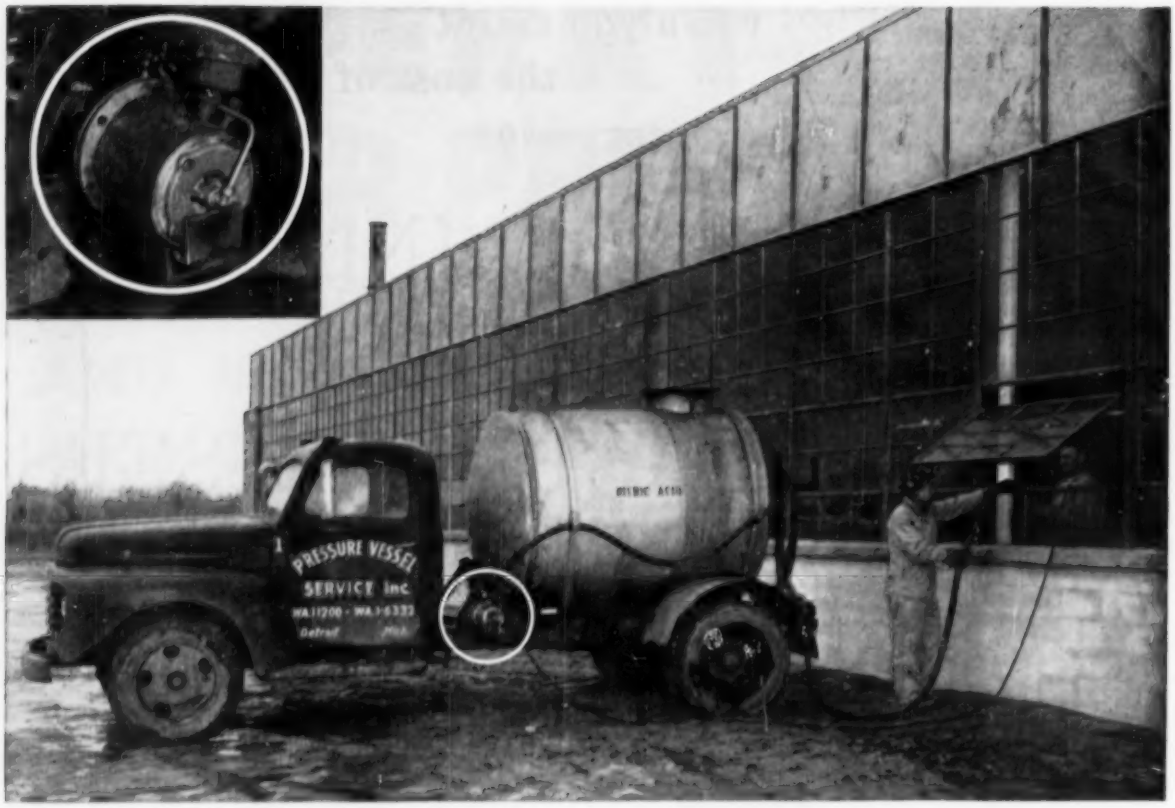

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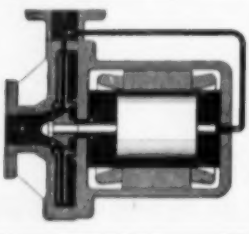

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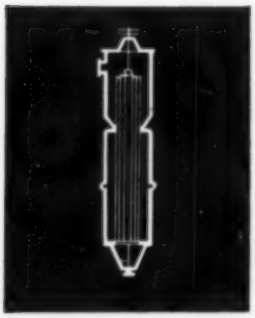
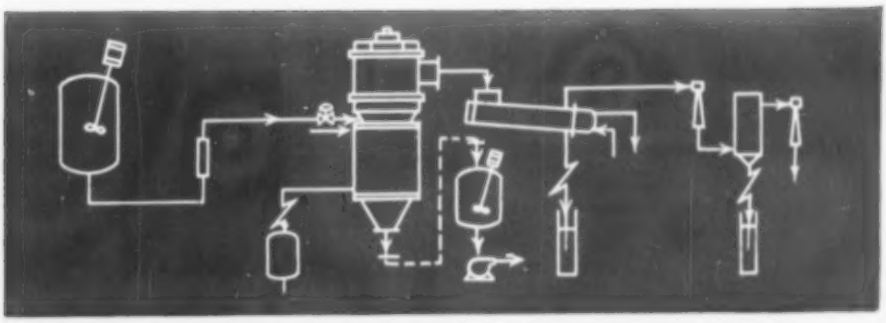
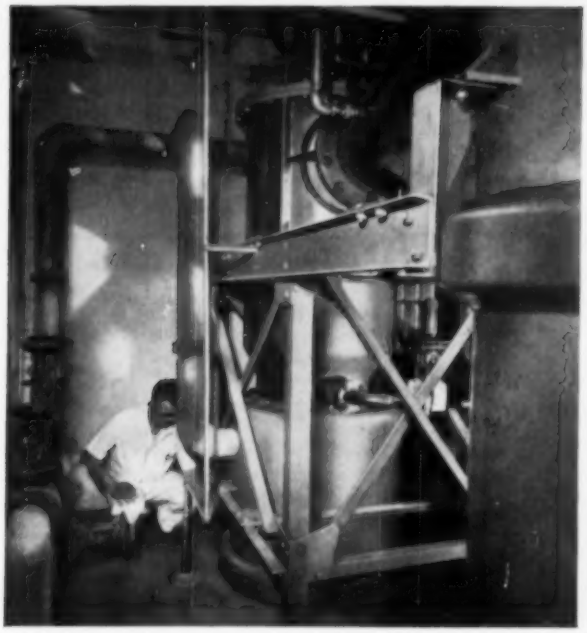
First in the field...*process proved*







High Concentration of Heat-Sensitive Products with a Turba-Film Processor at E.R. Squibb & Sons

Twenty-four hours a day, seven days a week, a Turba-Film® Processor at the E. R. Squibb & Sons Division, Olin Mathieson Chemical Corp., accomplishes high concentration of heat-sensitive solutions without impairment of essential values. This is possible because of the mechanically aided turbulent, thin, falling film; and because of lower processing temperature, minimum hydrostatic head and extremely short residence time. Product quality is maintained by close control of feed-rate, heat input and operating pressure from a central point during the continuous, single-pass operation. After leaving the Turba-Film Processor the concentrate is crystallized as high-purity antibiotics.

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Marginal notes

WORK SAMPLING—A Device for Chemical Process Analysis?

Work Sampling, 2nd ed., by R. M. Barnes. Wiley, New York (1957), 284 p., $7.95.

From time immemorial, ever since one man worked for another, the time required by the worker to complete his tasks has been subject to observation, analysis, and perhaps some adjustment. Certainly the person being observed rarely enjoys this scrutiny, particularly if the period of observation is for a considerable length of time. It is for this reason that *work sampling* has been developed. This is a technique which includes among its modern tools the use of statistical analysis to interpret the information collected via the stopwatch, thus requiring only random observations of the worker at his tasks. Result: less time and effort per measurement, better employee relations, more measurements per team-week.

The technique of work sampling is described in working detail in this interestly written book which first appeared in 1956. The reader is prepared to understand the technique by a brief review of statistical concepts and control charts, with the latter helping in the planning of sample size. The procedures for determining *time standards* (how long it should take to do a job), *performance sampling* (how well the job is being done), as well as other functions useful to process design or managerial fathoming, are illustrated by examples.

A pertinent question is to what degree work sampling can serve the case of the modern semiautomatic type of plant common to the chemical process industries? To aid the reader in answering this question as it relates to his type of interest, two articles appearing in next month's *CEP* will in effect debate this point.

OPSEARCH—An Introduction

Introduction to Operations Research, C. W. Churchman, R. L. Ackoff, and E. L. Arnoff, John Wiley & Sons, New York (1957), 645 p., $12.00.

Reviewed by Gifford H. Symonds, Esso Standard Oil Company, New York, New York.

Half of the text in the present volume is devoted to a description of the place of Operations Research in industry and business. The other half presents the methods of Operations Research not as a collection of miscellaneous case histories but as an organized and orderly review of procedures designed to give an understanding of the subject matter. The text, therefore, will appeal to prospective consumers and users of Operations Research, that is, management people, who wish to evaluate OR and to understand its procedures. It will appeal also to potential practitioners with its introduction and voluminous references which will assist further education in each OR subject.

The principal idea of OR concerns an over-all approach to the system as a whole in decision-making problems. It is stated that a new class of managerial problems has been created by the segmentation and specialization of the management function. OR provides managers with a scientific basis for solving problems involving the interaction of the components of an organization.

According to the authors, the OR team, an essential feature of OR, needs to know the nature of the operations in which the company is involved and how the control of the organization is maintained. The team probably should study the company as an organized communications system which controls a productive process. Such a survey seems to be valuable not only in identifying useful problem areas, but also in identifying and quantifying the organization's objectives which it is hoped to optimize through the OR study. Good communication by the OR team and the company executives seems to be important since the problem may change its aspects as the work proceeds and new investigations may be in order.

The OR team is composed of people with different scientific and engineering backgrounds and training so that a wide variety of analytic techniques and viewpoints can be used in the problem solution. A typical Operations Research team would include both behavioral and physical scientists, a mathematician, one engineer, and one company man. It is noted that operations research on a supposedly straightforward engineering problem sometimes becomes concerned with economic, social, or psychological factors, and the mixed research team is helpful in coping with such problems.

Consideration of the values involved and the ultimate objective of the OR work is stressed greatly. Any initial statement of the problem should be thoroughly reviewed by the OR team in order to provide an accurate diagnosis of the situation. The possibility of making an analysis of the organization is developed since an adequate communication and control system is necessary in order to apply the results of an OR study. In some cases, revamping of the organization's communication and control processes would be required. An introduction to organization and communication methods is included in the book.

Formulating the OR problem is usually a sequential process since the initial problem is subjected to almost continuous and progressive reformulation and refinement during the course of the research work. The components of an OR problem include first, the identification of the individual or group who is the decision-maker; second, the analysis of the objectives of the decision-maker; third, the study of the system or environment embracing both machines and men; and, finally, the designation of the alternative courses of action or policies facing the decision-maker.

The central theme of OR is the construction of a scientific model to represent the system under study. The primary function of a scientific model is explanatory rather than descriptive. The models include iconic models, which look like the system under study; analogue models, which represent the properties of the system under study by a different set of properties; and, finally, symbolic models, which are mathematical or logical in character, permitting prediction and control of the system under study. In fact, the development of theory in scientific activity becomes identical

(*Continued on page* 16)

Corrosioneering News

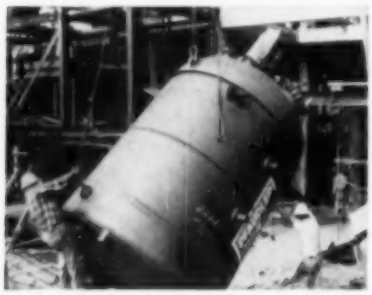
Quick facts about the services and equipment available to help you reduce corrosion and processing costs.

Published by The Pfaudler Co., Rochester, N.Y., U.S.A.

How 15 men put Pfaudler equipment "on stream" and keep it in prime condition

The man hurried up the ramp into an airplane. As soon as he landed, a taxi rushed him to a train. Another taxi sped him to a ship. Ashore, still another taxi carried him to his destination; a Pfaudler customer's plant.

This performance, although out of the ordinary, illustrates well the first duty of our fifteen field service supervisors: when there's trouble, get there fast; downtime costs money.



Supervision of installation crews at the plant site. Pfaudler field servicemen save time, often avoid equipment damage, and assure operational efficiency. To help get equipment into place quickly, lifting lugs are conveniently located on all Pfaudler vessels.

The eldest of this group has been servicing Pfaudler equipment for 45 years. The "youngest," relatively new with Pfaudler, has 20 years' experience in chemical processing.

That's the second mark of these men: experience and ability: ability to hire and direct a crew of riggers, ability to actually repair equipment in the field.

Recently, in an unusual case, a customer's plant was badly damaged by fire. A Pfaudler tank needed extensive repairs, so the servicemen removed the tank from the line, shipped it to our plant, and reinstalled it at the customer's plant—all within a single week.

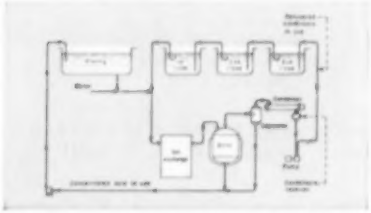
That's another dimension of the job: making quick decisions and knowing when to request assistance from the production, research, and engineering men in the home plant.

The key words for the whole program are customer service—service in helping to get a plant started, routine service to assure long use life, and prompt repair service to keep downtime to an absolute minimum.

Users of Pfaudler process equipment know that this Field Service Department is itself just a part of our complete program which also includes frequent seminars on corrosioneering, maintenance classes, some of which are held in customer plants, a Customer Advisory Board to review new designs, and complete laboratory pretesting facilities.

Platers turn waste disposal into extra profits

Like many other industries, platers have long had the problem of getting rid of contaminated waste. With the help of Pfaudler equipment and engineering, many of them now reclaim valuable materials and re-use solutions they used to dump.



In the case of chromium plating baths, for example, water is removed from the dilute acid solutions to obtain a concentrated solution of plating strength. Polluted rinse water is no longer sent down the sewer.

With the new system, you intercept used wash water contaminated with chromic acid. Boiling in a still removes most of the water. The recovered acid returns to the plating tank and the water, recovered in a condenser, returns to the wash system.

These wastes are extremely corrosive. Still, the materials selected for equipment must give long, economical service life. It is also very important that the system itself does not contaminate the recovered solutions.

On both counts Pfaudler glassed steel has been found to be the only material that will resist the corrosive attack of acids such as 25% to 45% chromic acid solution.

Similar systems can be used to recover sulfuric acid solutions, some metal cleaners, nickel and nickel salts, copper, gold, silver, and various cyanides.

An article on the system described appeared in the November 1956 issue of *Products Finishing* magazine. Send the coupon for Reprint No. 522.

Advanced heat exchanger designs in new bulletin

Bulletin 949, just off the press, contains 28 pages of information data on Pfaudler's flexible standard and custom-built heat exchangers, including applications, types available, design specifications and operating characteristics.

You can get *two-week delivery* on stainless steel tube sheet with carbon steel shell-type, single- and double-pass fixed tube shell heat exchangers. Capacities: 56, 104, 149, 216 and 316 sq. ft. Larger sizes can be supplied in four to six weeks. Custom designs include titanium, zirconium, karbate, etc.

Get the complete story on Pfaudler heat exchangers by checking coupon.

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Dept. CEP-107, Rochester 3, N. Y.

Please send me the information checked:
☐ Recover that plating waste, Reprint No. 522; ☐ Type "W" Drives, Bulletin 951; ☐ Heat Exchangers, Bulletin 949; ☐ Buyer's Guide, Bulletin 947.

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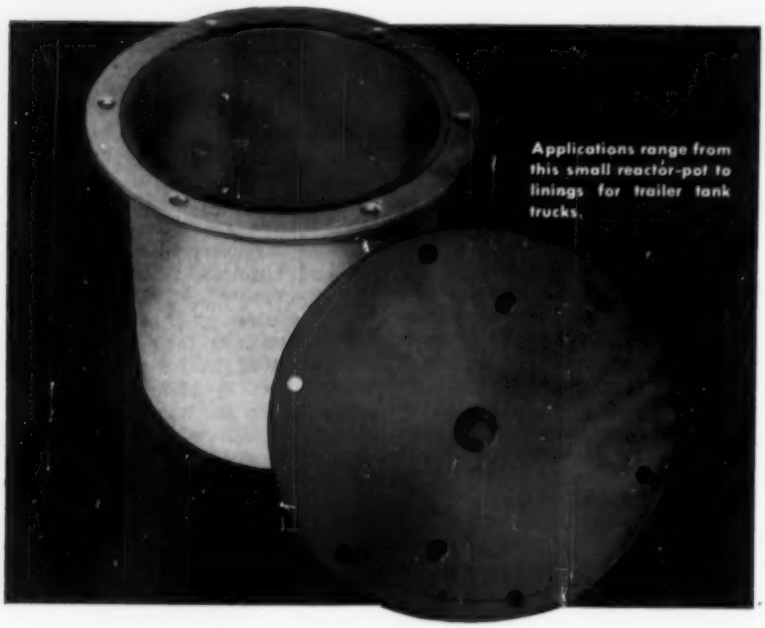
now make any vessel

CHEMICAL RESISTANT...



...with KEL-F LAMINATE lining

Here is a method for making ordinary plant equipment (new or existing) resistant to gases and liquids as corrosive as fuming nitric acid—and at reasonable cost.

KEL-F Laminate comprises a tough, shatterproof, abrasion-resistant, frictionless surface of KEL-F* fluorocarbon plastic, bonded to a glass-cloth backing for maximum adhesion. It is readily cemented to any material of construction—metal, wood, concrete, etc.—and over a variety of contours.

KEL-F, being a thermoplastic resin, seams may be "heat-welded". The result is a continuous surface having zero water absorption and extremely resistant to acids, alkalies, oxidants and solvents at temperatures up to 350°F.

KEL-F Laminates are manufactured by the United States Gasket Company, pioneers and leaders in fluorocarbon plastics, and are available for installation by certified applicators. Write for further information and the name of applicator nearest you.

UNITED STATES GASKET COMPANY, Camden 1, New Jersey

*Trademark, Minnesota Mining & Mfg. Co.

100 gal. Tank handling acid fluorides, lined with KEL-F Laminate.

United States Gasket *Plastics Division*

OF THE GARLOCK PACKING COMPANY

Marginal notes

(*Continued from page* 14)

with symbolic model construction.

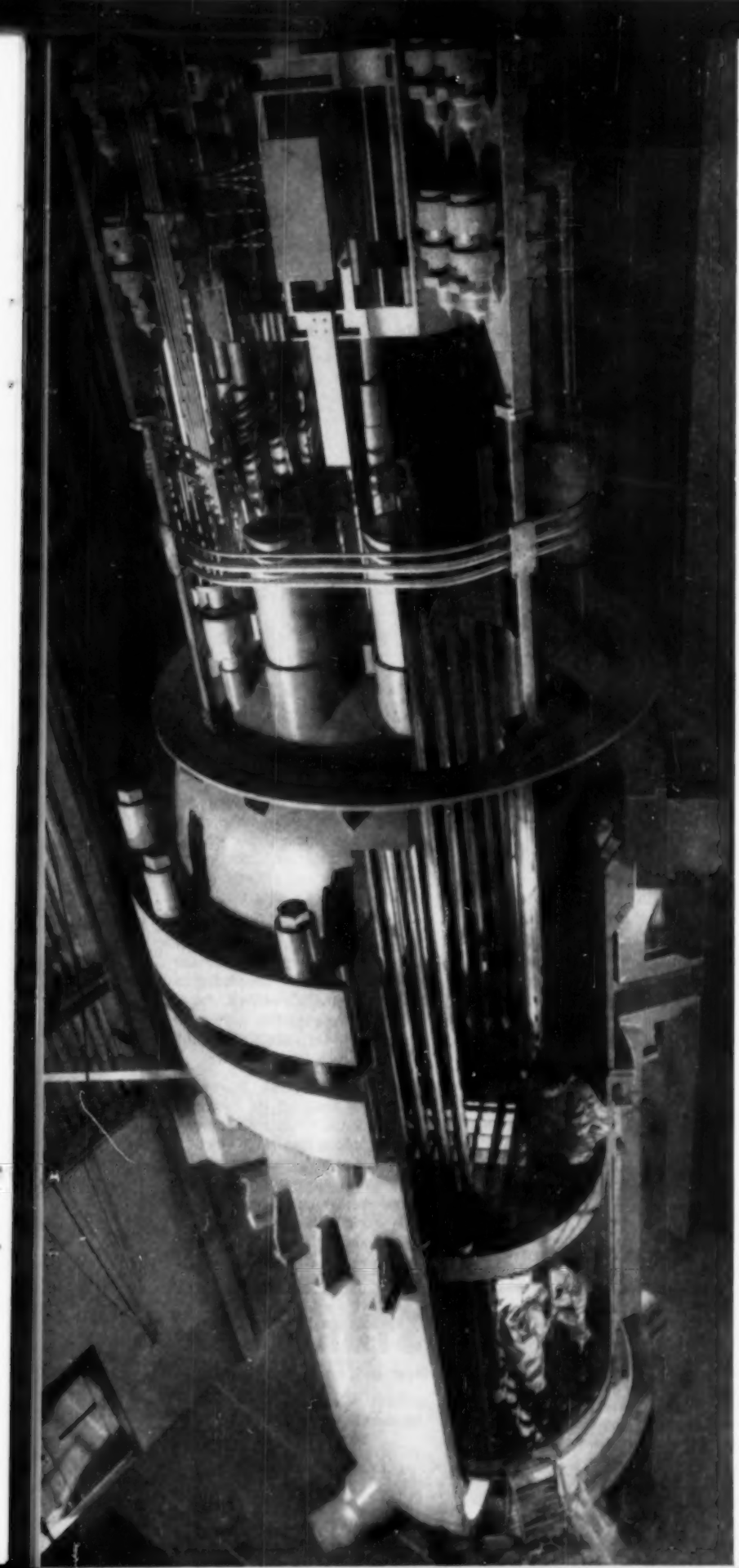
Engineers are usually quite familiar with the application of iconic models in pilot plant operation, of analogue models in the use of flow charts, and of symbolic models in mathematical representation of unit processes. The application of model construction to the area of decision-making, however, is new and will require a new attitude of scientific inquiry into an area generally listed as basic assumptions in the formulation of the usual engineering problem.

This book cannot be considered a handbook for applying specific tools to the solution of OR problems but simply an introduction to the method of going about the solution of such problems. The extensive bibliography at the end of each chapter is of great assistance in gaining additional background on each subject. The language is straightforward and should be easily understood by any engineers who may have reference to this work.

It is abundantly clear, however, that the members of an OR team should have some background in probability theory and statistical methods in order to have a satisfactory grasp of the methodology of Operations Research. Although engineers usually are well trained in model building, they often do not have the required background in probability and statistics. This background will have to be supplied in order to work effectively in Operations Research.

The authors believe that the research people should be concerned with controlling and implementing the solution of operations research work. Methods for testing the model, setting controls over the solution, and obtaining implementation are given. The place of the OR group in the organization is also discussed. Whereas the initial setup is not important, it is essential that the OR group have the same freedom for research as any other scientific research. OR cannot be successfully contained within a too narrowly segmented organizational unit.

This book, the first introductory textbook on Operations Research, is based on the lecture material for the short course in Operations Research offered by the Case Institute of Technology. Prior books are Methods of Operations Research by P. M. Morse and G. E. Kimball (1950); Operations Research for Management by J. F. McCloskey and F. N. Trefethen (1954); Operations Research for Management, Vol. II, by J. F. McCloskey and J. M. Coppinger (1956). These earlier works are concerned almost entirely with the methods of carrying out operations research studies and contain military as well as industrial applications.



Designing reactor for nation's first full-scale nuclear power station

A nuclear power plant must be designed to safely produce maximum power. Because the nuclear reactor can produce almost any level of heat output, its limitations must be set by the ability of its cooling system to remove the power.

At Bettis Atomic Power Division, one of the key engineering problems in the design of the Pressurized Water Reactor was the development of fuel elements which could handle maximum heat production while avoiding melt-down or burnout. Reactor thermal designers used a combination of analytical and experimental efforts to determine the safe operating level of a reactor. Computations of melting and phase transformation temperatures, as well as the temperature difference between the temperature of the bulk water flowing past a fuel element and the surface temperature of the cladding, were necessary.

Of course, thermal and flow problems are also intimately connected with the mechanical design of the reactor. To mention only one example, stress problems are generated by the high non-linear temperature gradients in the fuel elements and structure. Analytical treatment of the thermal stresses in combination with pressure and mechanical stresses is particularly difficult because of complex structural geometries and non-uniform radiation heating. Other design problems include materials, operational reliability, warpage, tolerances, alignments, and maintenance.

This is only one example of the challenging opportunities available at Bettis Atomic Power Division. If you are interested in a career with the new and expanding nuclear power industry, send your résumé to: Mr. M. J. Downey, Bettis Atomic Power Division, Westinghouse Electric Corp., Box 1468, Dept. A205, Pittsburgh 30, Pa.

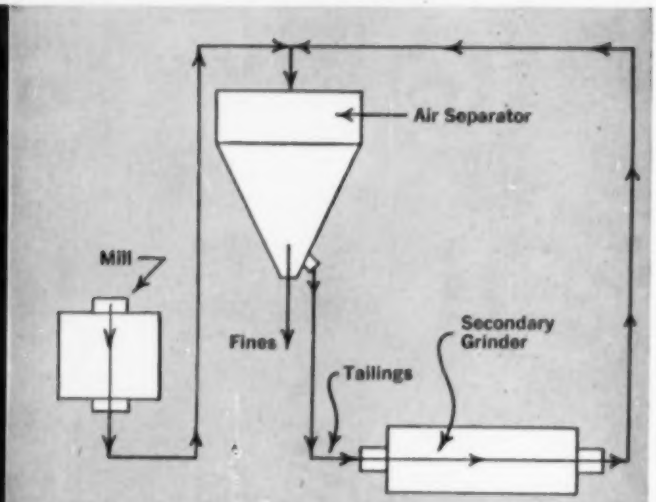
◀ This mockup of the pressurized water reactor for the nation's first full-scale civilian nuclear power station rises four stories tall complete to closure head and supporting structure. It was constructed at Bettis Atomic Power Division to assist scientist and engineers in the mechanical design of the actual power plant. Under Atomic Energy Commission sponsorship, the Shippingport Power Station will be operated by the Duquesne Light Company some time in 1957.

BETTIS ATOMIC POWER DIVISION

Westinghouse

Stop Overworking Grinding Mills

FEED SPOUT
Sturtevant Air Separators come in 9 models, diameters range from 3 to 18 ft.
TAILINGS DISCHARGE
FINES DISCHARGE



Secondary grinder runs open, starting circulating load through air separator. Desired fines are discharged, and oversize is fed to ball mill and then returns to air separator for further classification.

LET STURTEVANT AIR SEPARATION HELP YOUR SYSTEM PRODUCE UP TO 300% MORE 40 TO 400 MESH FINES — CUT POWER COSTS AS MUCH AS 50%

Fines that pass through grinding mills unhindered, serving only to increase the work load, can be quickly classified by a Sturtevant Air Separator operating in closed circuit. With all oversize automatically returned for further grinding, the result is production capacity impossible to achieve in single-pass grinding — as well as a better, more uniform product.

Closed circuit grinding and air separation is of proved advantage in *all* secondary reduction processes. Grinding mills are free to perform at top efficiency, their output frequently increased as much as 300% and power costs cut up to 50% (documented by 30 years of Sturtevant air separation experience in the cement industry). Further, attritional heat is dissipated by greater surface exposure.

Sturtevant Air Separators Keep Grinding Units At Peak Efficiency — Classify Feed Loads to 800 Tons Per Hour

Sturtevant Air Separators circulate production loads with exact control of air currents and centrifugal force. Simple adjustments make possible counter-action between the two to the point where a product of almost any desired fineness may be collected while coarser sizes are rejected.

A 16 ft. Sturtevant, for example, took a feed rate of 800 tph, containing only a small percentage of desired fines, and delivered 30 tph 90% 200 mesh, recirculating the oversize through the grinding circuit. (In the cement industry, Sturtevant units deliver up to 60 tph raw cement fines, 40 tph finished cement fines.)

Sturtevant's ability to engineer precise, high capacity classification for closed circuit grinding systems is the result of long experience with a wide variety of dry processes. Sturtevant designed its first air separator some 40 years ago — and has been pioneering developments in centrifugal classification ever since.

Current users of Sturtevant Air Separators include manufacturers of sulfur, soybeans, phosphate, chocolate, feldspar, sand, pigments, limestone fillers, abrasives, plasters, ceramics and cement.

Designed for precise separation of all granular materials, Sturtevant Air Separators have been adapted to other materials as well. Johns Manville, for example, uses a 10 ft. model to separate 3 to 6% undesirable rock from asbestos.

Ruggedly constructed, Sturtevant units are designed for minimum maintenance — at a Midwestern rock-crushing plant, a 10 ft. Separator operates outdoors year-round with only routine care.

For further information, request Sturtevant Bulletin No. 087. Write Sturtevant Mill Co., 135 Clayton St., Boston 22, Mass.

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CRUSHERS • GRINDERS • MICRON-GRINDERS
SEPARATORS • BLENDERS • GRANULATORS
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a commentary on the supply and demand for scientists and engineers

NATIONALIZATION of research and development in the United States

James C. DeHaven
Rand Corporation,
Santa Monica, California

The author suggests that changes in government contracting practices can help the so-called "shortage" of engineers and scientists by initiating procedures which will restore to research managers (1) a truer perspective on cost and value for research and development talent, and (2) the prerogatives of managerial decision on salaries.

From *Science to Fortune* and from the *Los Angeles Times* to *U. S. News and World Report*, one learns of the "shortage" of technically trained people. We are left little doubt of the "critical" nature of this "shortage" by reports from symposia on the subject held at meetings of myriad professional societies and from the numerous special commissions, committees, and task forces delegated to investigate and to suggest measures to alleviate these "serious shortages" both in the teaching and operating areas.

The number and characteristics of advertisements for specialized talents cause one to start asking a few questions. Why isn't there a similar sales campaign for jobs seeking medical doctors, lawyers, historians, poets, psychologists, musicians, economists, and undertakers? Obviously, because there is not the "shortage" of these trained people as there is for physical scientists. Why are these ads so largely for work on government research and development projects? The popular reply is that the huge government expenditures for weapon systems development and production have already sopped up so many physical scientists and engineers and the continued program requires so many more that a "shortage" of these trained categories exists. In addition, we aren't training enough new people with these skills to meet the demand—there is also a "shortage" of proper teachers to impart the desired knowledge and skills.

STATISTICS

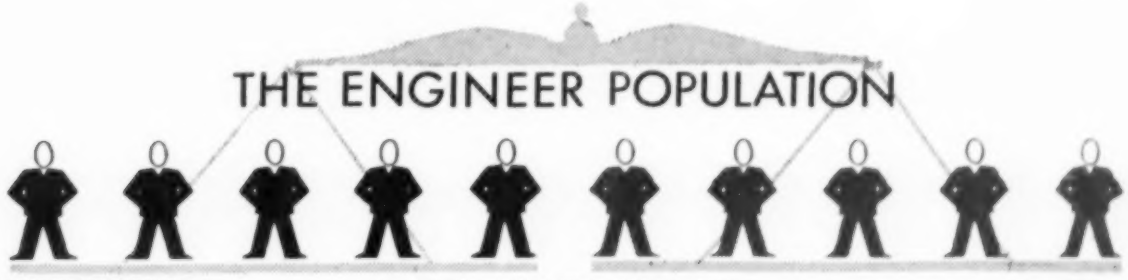
In 1953 there were 237,000 natural scientists and 633,000 engineers employed in these professions in the U.S. (3). There are 643,000 people who received Bachelor or first professional degrees in natural sciences still living (1953) in the U.S., and 529,000 engineers. (There has been a migration out of the natural sciences to engineering and other occupations.) In contrast, and to pick a few other available numbers, there are only 22,000 psychologists working at their trade, 47,000 social scientists, 114,000 in all other humanities and arts categories, 84,000 in dentistry. If absolute or relative scarcity, then, is our criterion of "shortage," many other professions are shorter than engineers and physical scientists.

We are led to believe that the security and welfare of the nation dictate the need for action; many actions are being taken and suggested, running the gamut from increased scholarship aid for engineering students to encouraging gifted elementary school pupils to become interested in science. However, a review of the literature on this subject indicates that little in the way of a critical examination of the problem has been undertaken. Stereotype panaceas are being applied without a real understanding of the nature of the problem. Some of the actions being taken may well cause the situation to deteriorate rather than improve in the long run.

What Is a "Shortage"?

A place to start is with a better understanding of what may be meant by the term "shortage." If one is foggy on the meaning of the term "shortage" then one can't be any less foggy on the term "critical shortage." Sometimes the word is used to mean absolute scarcity. Thus, water is short in the middle of the Sahara desert. There is a "shortage" of women in San Quentin. Is there a "shortage" of scientists and engineers in this sense in the U. S.? (See box at left.)

Sometimes the word "shortage" is used to indicate any reduction in supply to which we have become accustomed. Thus, "rainfall is unusually light this year so water will be short." If this criterion is applied to engineers and scientists, no "shortage" appears. Both in absolute total numbers, in numbers of new graduates per year, and in percentage of engineering and science degrees of all degrees granted, the output has been increasing. At other times a "shortage" is said to ex-


THE ENGINEER POPULATION
50% GOVERNMENT DIRECT AND BY CONTRACT
The salaries of about 50% of the engineers involved in R & D activities in the U. S. are affected by federal government contract procedure (Engineering Manpower Commission).
50% INDUSTRIAL AND OTHER

ist when monopolistic or other practices occur which limit supply artificially. Thus, consumer goods are "short" in Russia because the government limits the production of these items. Or, there is a "shortage" of coffee because the coffee producing countries withhold, destroy, or otherwise synthetically limit the amounts made available to world markets.

Have engineers and scientists engaged in monopolistic practices designed to limit artificially the numbers in their profession? If they have, their efforts are significantly ineffectual. The numbers of both have been increasing at a steady pace. No attempts have been made to limit the number of students entering science or engineering courses, or to limit the number of schools which can grant degrees in science or engineering. Nor is there an effective limitation placed on the practice of engineering by state licensing restrictions. On the contrary, engineers and scientists individually and in their societies are actively promoting science and engineering as careers. As a matter of fact, engineers and scientists have notably abstained from actions which will limit their numbers.

For purpose here it will be more instructive to consider the term "shortage" in a different manner. Recall the great meat shortage of 1946. Meat consumption was by all previous standards quite high, yet for the housewife meat was always hard to find in the shops. The reason was that, because of the high incomes being earned, more meat was being demanded by consumers than could be supplied by producers at OPA prices.

This type of "shortage" is neither absolute stringency nor a fall in supply, but rather a situation in which more of a commodity is demanded in the market than is being supplied *at the going price*.

The meat shortage disappeared soon after OPA controls had been lifted. Meat prices rose—with the result that housewives demanded less meat and suppliers offered more. In the end, supply and demand were in balance.

In "Demand and Supply of Scientific Personnel," Blank and Stigler (*1*) state that if the determining factors or variables of the supply and demand functions are allowed to vary (that is, if the market is free), they will move in such directions as will equate the quantity supplied and the quantity demanded. If, for example, the number of engineers that employers seek to hire is in excess of the number available, the salaries of engineers will rise. The higher salaries will invariably reduce the number demanded, and sooner or later increase the number seeking employment. *In free markets*, therefore, the actual number of engineers (and scientists) employed in a given past year represents both the number demanded and the number supplied (*1*).

Table 1.—Index of Median Salary.

(1929 = 100) (*1*)

Year	All engineers	Less than 1 year's experience	9-11 years' experience	30-34 years' experience
1929	100	100	100	100
1932	81.3	74.5	78.6	81.4
1934	72.7	73.8	69.7	73.3
1939	95.8	85.9	82.2	103.6
1943	122.5	146.3	115.4	117.4
1946	135.6	155.0	129.9	131.2
1953	173.4	238.5	177.8	162.7

Possibility of Price Control

It is easy here to miss an important point, to assume the market is completely free, and to conclude that there is no "shortage" of engineers and scientists in the U. S. Up to this point factors on the supply side of the market which might create situations of imbalance have been touched upon. It is with respect to demand and not supply where "pay dirt" is struck in explaining the phenomenon of "shortage" of scientists and engineers for research and development. The claim is made here that the market is not free on the demand side for engineers and scientists, but rather effective direct and indirect price controls exist which tend to keep the price below that of a free market. It is proposed that controls occur because the Federal Government currently finances directly or through contract over *60%* of the research and development work under way; and further, in attempting to minimize the costs of its research and development program and to prevent the loss of its directly employed engineers and scientists, the government has by contractual and other devices extended price control to most private organizations conducting research and development for the government. Perhaps, without either private contracting organizations or the government realizing the trend, science and engineering in the U. S. are rapidly becoming nationalized.*

If this hypothesis can be supported, some important measures may be taken to alleviate the situation to the great advantage of the nation and the future caliber of the professions in question. If this price control mechanism is really the basis for this condition, then many of the measures now being taken or suggested to increase the *supply* of engineers and scientists will be either ineffectual, or actually decrease the number, or degrade the quality of our future engineering and scientific resources.

Changes of Income for Technical People

One may ask: "how can there possibly be any controls on the salaries of scientists and engineers? Just look how tremendously starting salaries have increased in recent years!" True, starting salaries have increased and so have salaries for those with, say, 10 and 30 years experience. Table 1 shows how these various salary categories have changed with time since 1929.

It should be noted especially how the salaries for starting and for the different experience levels changed about the same percentage up until the war years. From here on, as the government entered the market on a large scale, the starting salaries increased at a much faster rate than for the more experienced. So, in 1953 we find starting salaries have increased 138.5% over 1929, while the median salary for all engineers has increased only 73.4% in the same period. A leveling process like this in income stream for a wage or salary-earning category is certainly not conclusive proof that a control mechanism of some sort is at work, but may be suggestive of some such measures. It might be argued, for example, that since about 1941, the value of starting engineers has been changing in respect to those with more experience. Thereby, the lesser income increase for the experienced merely reflects their lesser worth vis-à-vis those who are newly trained.

It is instructive to examine income stream profiles for some previous year and for a recent year to see the change which has taken place. Figure 1 shows

* Nationalize—to vest in the national government the control, ownership, or the like, of. —*Webster's New International Dictionary*.

such median streams for engineers plotted for 1924 and 1953 in constant dollars. The starter in 1953 does much better than his 1924 antecedent. But, after about 12 years experience, engineers now have a significantly lower percentage increase in income than in 1924. Even allowing for the discounting of future earnings, the 1953 candidate engineer had a lower stream of income to anticipate than the candidate engineer of 1924.

Not only is the absolute total income less for engineers now, but the relation of their income to many other income categories has deteriorated to a rather significant extent. Table 2 shows the status of median engineering incomes for different years compared with other income and wage categories, all compared to the relative status in 1929. It can be seen that comparing 1929 and 1953, engineers' incomes have increased only about 67% as much as for office and factory workers. Engineers have not done as well as physicians or dentists. They have about kept pace with teachers and lawyers. It may well be that the social worth of engineers has changed in respect to these other categories and this change is reflected in their price. Perhaps the number of engineers has increased in comparison with the other categories so that the decreased price reflects this greater supply. If this is so, how can one possibly speak of a "shortage" of engineers?

When copper supplies are reduced by general strikes in the industry, the price of copper in comparison to other metals immediately rises. If there were a "shortage" of engineers one might expect an increase in their price compared to other categories of skills. But, this phenomenon has not occurred. It is proposed that the answer lies in the fact that at least 60% of the engineers and scientists in research and development work directly or indirectly for the Federal Government, and that by accident or purposeful intent, and through institutional means. This situation has resulted in a ceiling, or better, an "inversion layer," or lag, in the price of these engineers and scientists.

How Controls May Operate

The Federal Government and its agencies, especially the military, who are the largest customers for research and development, have an interest in getting the most for their money. They have the additional problem of determining the criteria of performance for research and development work. It's easy to let contracts for uniforms, or guns, or food, because exact quantity and quality can be specified in advance. Contractor performance is easy to determine. This is not so for research and development work.* As a consequence, procurement policies have evolved and been applied on a wide scale for research and development, which limit the range of detailed management decision. The apparent philosophy back of this trend is, "Well, we (the government) can't measure the performance of a research contractor, but we can insure, by disallowing certain costs, that he doesn't spend our money in ways we consider to be extravagant or unwise." Contractors have generally gone along with these contracting practices because to a large extent this type of contract also insures them against losses and provides a modest profit whatever their performance may be. These contracts, however, tend to narrow drastically the range of alternatives for managerial decision. Essentially every management decision, including salaries for scientists and engineers, is subject to approval by a government contract officer.

Managers may deny that many salary increases are disallowed by the contract officers. Even if this is so, it is suggested here that research managers under government contract have developed sensitive antennas for feeling out the criteria by which contract officers allow or disallow such increases, and stay within these perceived boundaries.

* If exact specifications for the research and development are defined, the contractor is uncertain of the costs to accomplish the objectives. If firm objectives are not established, government agencies feel they have no measure of contractor performance.

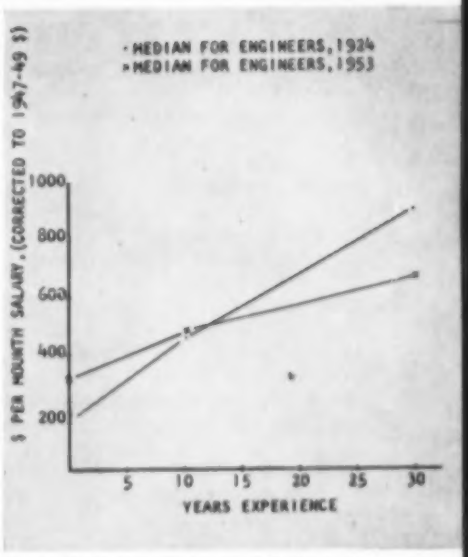


Fig. 1. Median income stream profile for engineers, years 1924 and 1953.

Table 2.—Index of Ratio of Median Engineering Salary to Average Wage and Salary Net Income of Selected Occupations, Benchmark Dates, 1929-53 *(1)*

	Ratio to earnings for white collar workers	Ratio to earnings for manufacturing wage earner	Ratio to net income for lawyers	Ratio to net income for physicians	Ratio to net income for dentists	Ratio to salaries of teachers
1929	100	100	100	100	100	100
1932	102	109.1	108.3	133.7	139.9	79.9
1934	93.6	97.3	95.4	112.4	129.8	.....
1939	106.4	108.5	120.8	118.3	132.1	101.4
1943	83.2	76.0	107.6	72.2	86.3	116.3
1946	80.9	83.1	108.0	69.4	90.7	119.6
1949	69.9	70.8	97.1	63.1	84.7	102.4
1950	67.6	67.6	93.8	61.3	83.1	101.5
1951	66.2	65.4	97.0	59.5	83.5	97.8
1952						99.4
1953	67.9	66.1				

Effects of Possible Price Control on the Professions

Office or factory workers don't have so high a percentage of their numbers working on government contracts (especially cost-plus-fixed fee), and have organizations in the form of unions which can exert unified counter-pressures against attempts to apply price ceilings. In contrast, the largest number of scientists and engineers in research and development work directly or indirectly for the government, and have shown no taste for bringing unified action against the price ceilings applied. As a consequence, the price of engineers and scientists has deteriorated in respect to these other categories in the last fifteen years.

The phenomenon called "shortage" results. Young people in college are not attracted to the engineering profession as they are to others more favorable on the life-income-cost-of-training basis. Because the price of engineers is depressed absolutely and in respect to skilled workers, they are not used so effectively as they think they should be in their occupations (*2*). They are substituted for skilled workers, draftsmen, technicians to a much greater extent than would otherwise be so if their price were higher. An increase in their price would make more engineering skills available immediately. It would become economic then to free engineers for use on jobs for which they are especially trained and substitute less skilled and trained workers for the more routine parts of their jobs.

Corrective Measures by Government

If the situation is like that postulated here, what actions can the government take to alleviate the causes of the situation? The government certainly wants to get the most for its R and D dollars, and it does require some scientists and engineers in its employ. There is the problem of contractor performance evaluation. It is proposed here that the government agencies investigate and initiate contracting practices which will insure that the absolute costs for the R and D program will be held in line by competitive bidding among candidate contractors and restore to research managers the prerogatives of managerial decision as to the allocation of their resources for the best accomplishment of their work. If managers decide the best course for their organization is to pay high prices for high caliber engineers and scientists and maintain a high ratio of technicians to professional, this course should be perfectly open to them. Thus, freedom of the market for these professionals is restored. If and as the price of these categories increases, the supply will also increase by (*1*) encouraging new entrants from college, (*2*) reentry into the professions by those who have migrated to other jobs, and (*3*) making more efficient use of present professionals to their highest capacities.

True, if the price in the "open" market increases, the government may lose nearly all of its own scientists and engineers who are on the civil service scale. But, the same course is open to the government in these cases as the military has already followed for the cases of physicians, dentists, nurses, and veterinarians. An extra bonus salary in-grade for these categories might be paid in civil service. The amount of extra payment required to retain the desired professionals can be determined approximately by the going price in the "open" market.

In a very real sense the problem of criteria of research performance is the same whatever type of contract may be used. No one pretends that the present contract officer services have any influence on the technical quality of the work performed. They merely insure that individuals don't line their own pockets with government money without going through conventionally accepted motions. The real incentive for quality performance for either cost-plus-fixed-fee or fixed price contracts, for example, is the desire of the contractor to stay in business and to make money. If renewal of contract or contracts for new work is dependent on past and current performance, there will exist the necessary incentives for quality performance. The important point is that the contract should be such as to free the market for scientists and engineers by restoring managerial prerogatives to the entrepreneur.

Individual scientists and engineers, and especially the technical societies, and universities, should take a long, careful look at the present situation for engineers and scientists before engaging in the current promotional activities to increase the *numbers* in these professions. If these activities are successful, they may cause great harm to the professions themselves and irreparable damage to the resource of technical talents in the United States. If the market for scientists and engineers is freed, there should be no need for such promotional campaigns. The increased price should attract sufficient numbers of high caliber people to meet the demand.

As between industrial users of scientists and engineers for research and development and government contract users of the same kind of talent, the tendency will be for the contractor to be a residual buyer on the market. The value of the engineer to the contractor will approximately be equal to his cost, and the value of the engineer to the industrial firm may be much greater than his cost. Thus industry can bid slightly more for all the engineers which it can use until the next engineer it hires will be worth his cost, at which point government contractors enter the market for the rest. This is a possible explanation for the large ads for engineers for government research and development contract work. Within the range of prices which contractors can pay, there are not enough engineers and scientists available to fill the government demands *at these prices*. Industry has picked off all it wants for its own use at slightly higher prices. Government contractors are left to bid among each other under more or less a price ceiling for the rest, having only the promotional devices of advertising and fringe benefits such as climate, educational leaves, etc. to offer as incentives.

It should be stated here that one factor which may influence the size and number (but not the characteristics) of ads for employment on government-sponsored projects is that their cost is an allowable charge against cost-plus contracts. Their cost to the contractor may be considerably less than the cost to the government. But this same feature of cost-plus contracts applies to expenditures by contractors for salaries for engineers, scientists, and technicians. The cost to the contractor for obtaining additional trained people will be only the cost to him of obtaining the money from the government, not the actual salary price of the worker. This will distort upward his demand for these workers in comparison to, say, private industrial employers of these same talents, where every dollar spent on salaries is a dollar out of pocket.

Within the price levels imposed for each skill by contracting officers, the contractor will both seek more people and more of those with the highest skills than will private industry for its own work. The increased emphasis on hiring the highest skills occurs again because the price of the higher skills in comparison with the technicians is not truly reflected in their costs to the contractor. This bad feature reinforces the influence of the price ceiling in causing engineers and scientists to be inefficiently used for work which does not require their highest skills.

Possible Actions by the Professions

What may happen to our resources of scientists and engineers in the future if the mechanism proposed here is really at the root of the so-called "shortage?" Without direct action along the lines suggested here, the situation may tend to correct itself. Perhaps the potential population from which larger numbers of scientists and engineers may be obtained will not accept the current propaganda designed to increase the *supply*. In this eventuality, normal pressures on the price ceiling may help bring the price of scientists and engineers nearer their apparent social

(*Continued on page 28*)

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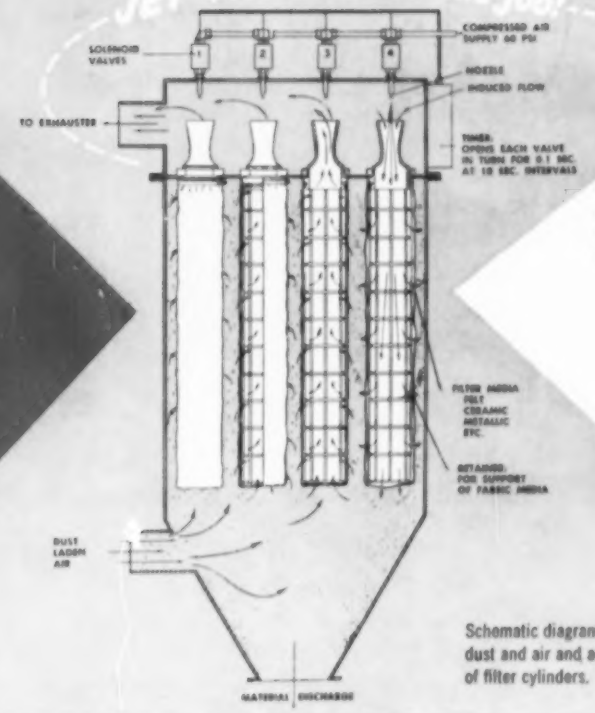
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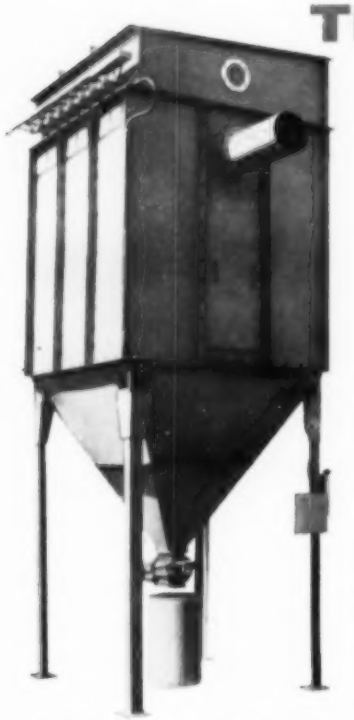

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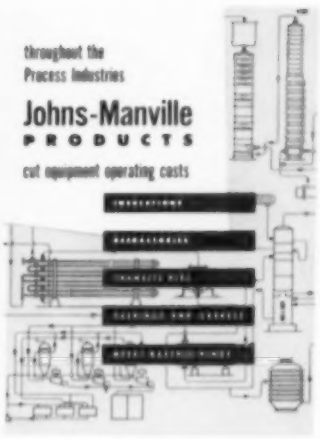

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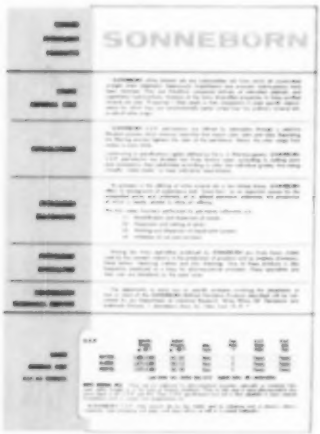

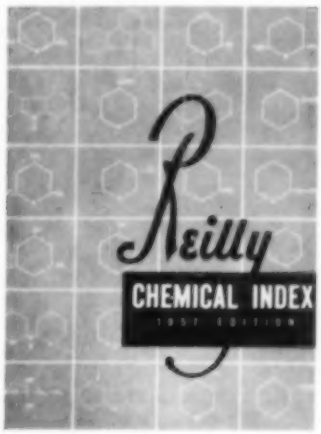

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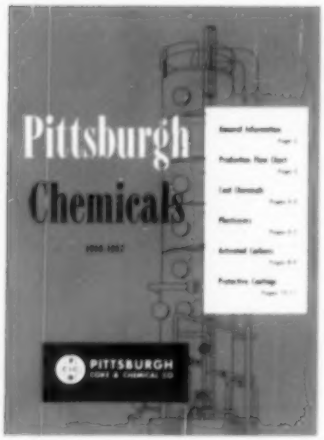

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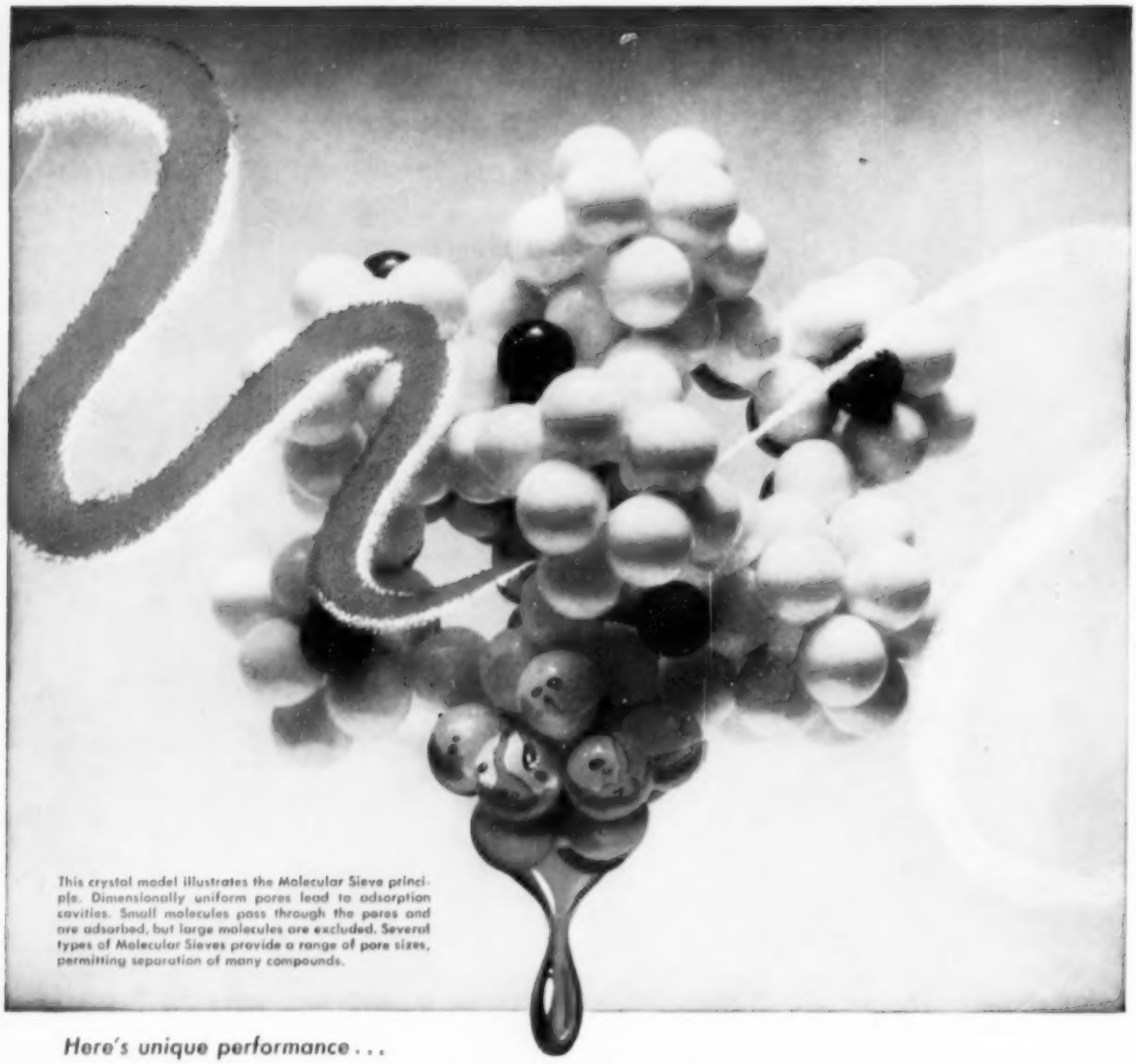

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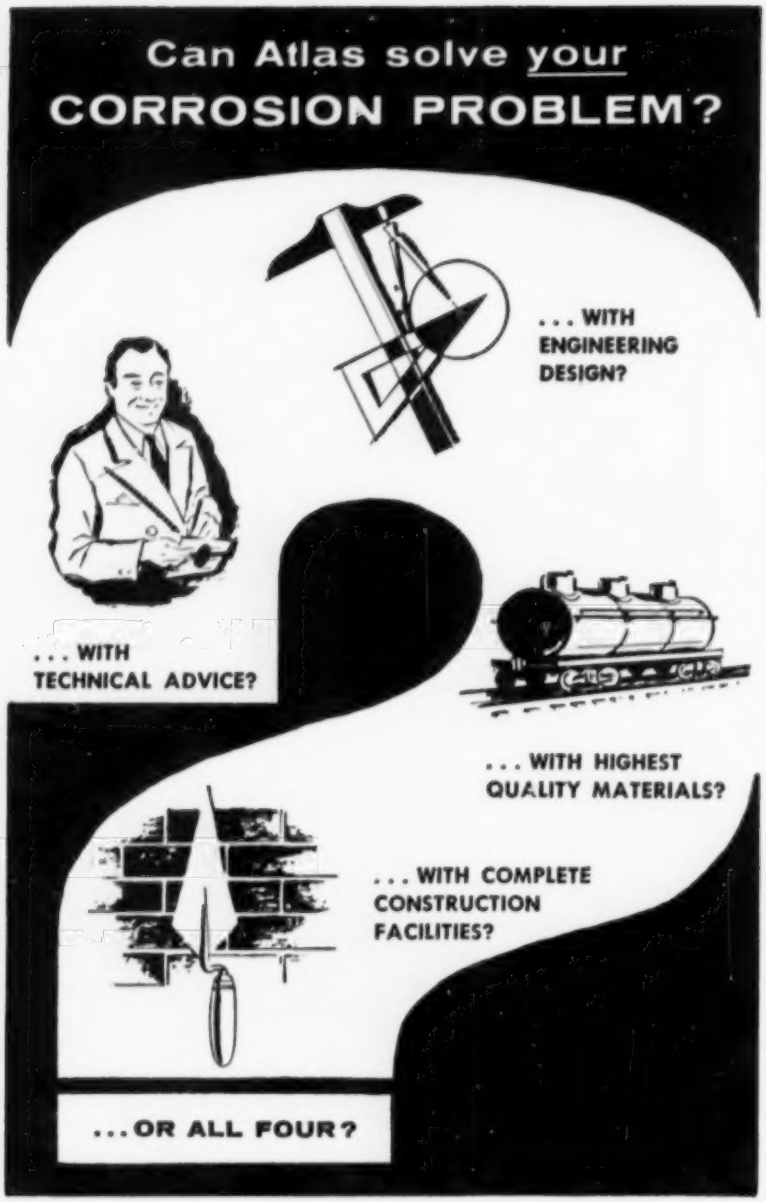
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NATIONALIZATION of research and development

(Continued from page 22)

worth on a free market, reducing the quantity demanded and increasing the effectiveness of their utilization to the satisfaction of all.

One might be even more seriously concerned if the propaganda to increase supply is effective. A situation would then ensue where the greater numbers of these professionals would become even more disillusioned and dissatisfied with both their standard of living and their use in work which did not require their highest skills. One might even find the scientists and engineers in this situation overcoming their distaste for unified action and see the formation of union-type organizations to further their interests. A much worse fate could hardly befall American science and engineering. The leveling action of conventional union-type agreements would promote mediocrity, discourage creativity, and make the profession unacceptable to the higher caliber college student seeking the most rewarding work.

Another reaction which may occur is a more severe internal "policing" by the professional or technical societies themselves. Engineering, especially, is still what the sociologists call a *marginal* profession—a profession in transition from that of unschooled skilled artisan to that of the university-trained scientist. Even today about 50% of those who call themselves engineers (in the census) have received less than four years of college training. A sort of guildlike action might be instigated by professional engineering societies. The dangers of such actions are that they are usually carried too far. Certainly quality can be improved, but the supply may be limited to such an extent that the cost of the professional affected may exceed his social worth. Thus a dollar invested in training for this profession is worth far more than a dollar invested in other types of training, and social imbalance results.

Acknowledgment

The author gratefully acknowledges the helpful comments and suggestions of the following associates at the Rand Corporation: A. A. Alchian, W. M. Capron, F. R. Collbohm, and R. A. Kessell.

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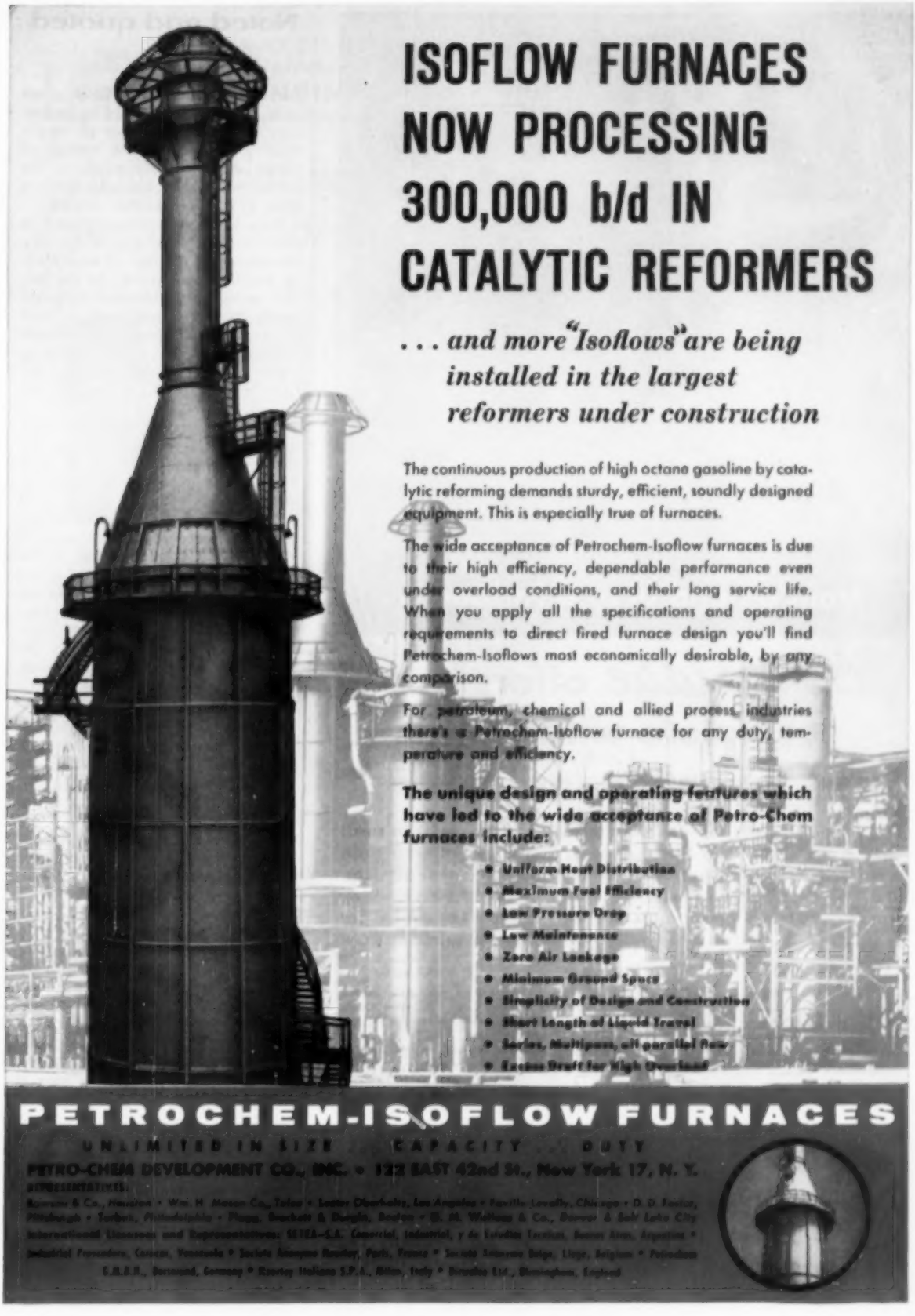

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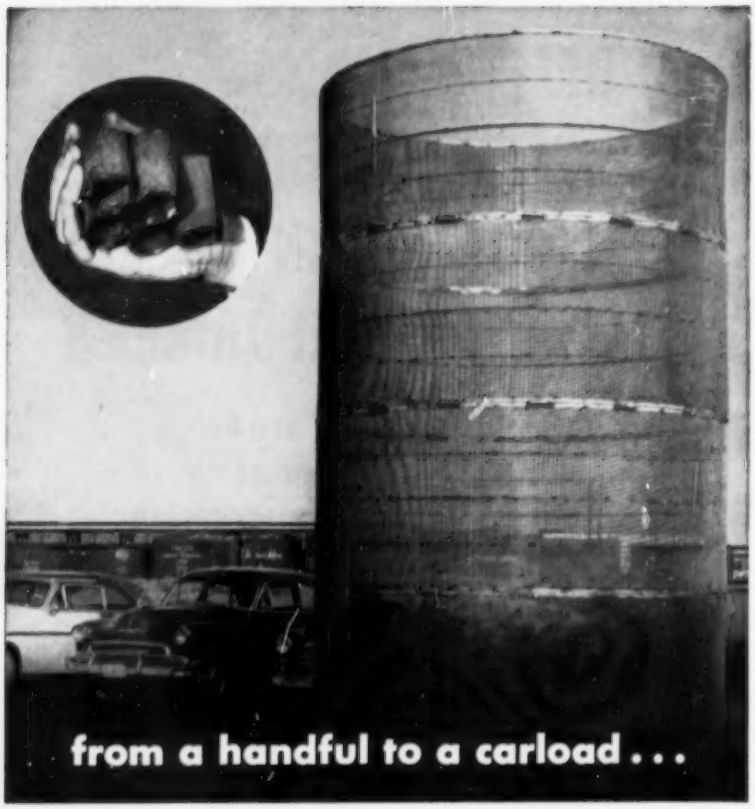

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(Continued from page 10)

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An engineer who relates his work to the welfare of society is more efficient as an engineer and very much happier as a man; but he cannot so relate it unless he knows the society it is intended to serve. Pope said it long ago: "The proper study of mankind is man." All the books that all the natural sciences have produced at last lead back to the central riddle of the universe, which is human nature. Successful study of that is the key to personal happiness because it opens the door to light and healing for the world.

Petroleum and the Chemical Engineer

The rapid development of the study of chemical engineering during the past 25 years has been due largely, almost entirely, to the development of the petroleum industry. Equally, the development of techniques in the petroleum industry has depended largely, almost entirely, on the study of chemical engineering. Professor Lewis of the Massachusetts Institute of Technology emphasized, in a talk some little time ago, that 35 years ago the petroleum industry found itself in the position of needing large-scale plant. Even in the United States such large-scale plant was in the main nonexistent. . . . The result has been that during the past 35 years chemical engineering has been called upon to develop plant for the continuous preparation of these fuels by means of physical and chemical changes. It was perhaps the need for continuous operation that first made calls upon the chemical engineer, who, of all professional engineers, was able to design, develop, and operate plants working in this way.

John A. Oriel, 1957 Presidential Address before The Institution of Chemical Engineers, London.

CONTRACT ENGINEERING with a difference

from initial negotiations . . . to "on stream" you deal with Badger principals

You first make contact with Badger through a Key Man as he works with you and your engineering staff in pinpointing your processing and economic problems.

The Key Man, acting in your behalf, takes your problem to Badger engineering specialists for preliminary study and evaluation.

With recommendations approved and construction underway, the Badger Key Man is still on the spot coordinating activities. He remains in charge until your project is complete.

AN engineering project handled by Badger is a group effort involving many highly developed skills. And from first contact until the project is complete these experienced specialists are headed by a Badger Key Man. More than just a sales engineer, he is always a Badger principal — always the Key Man in the execution of the project.

This sensible operating policy, which channels project liaison, coordination and administration through a company principal, is important to you and your project. You will find that most policy level decisions can be made on the spot as situations require. Further, the Key Man's depth of experience means you deal with an executive-engineer who talks your language — knows your problems and how to find their solutions.

Many clients say Key Man Policy is the Badger difference that makes the difference. Wouldn't it be wise to inquire how it could serve to make your projects more successful?

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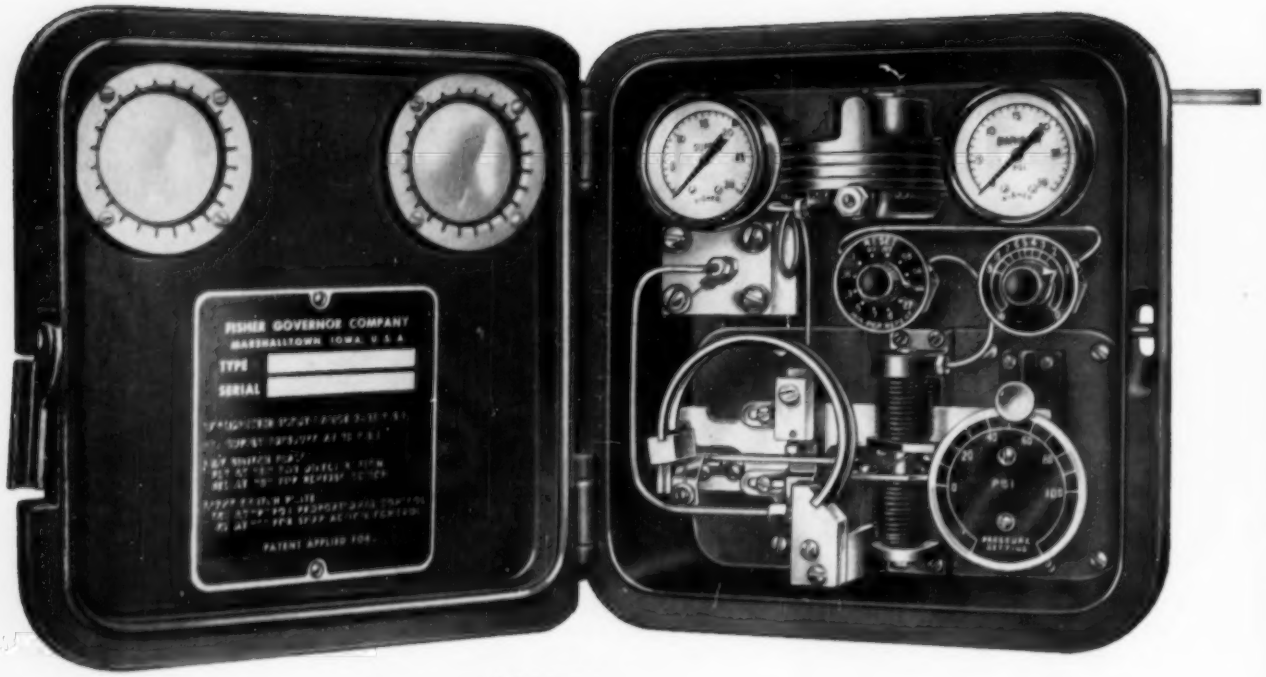
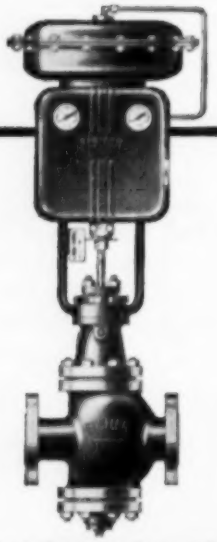
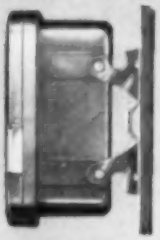




Any of the Wizard controllers can be yoke mounted on a diaphragm control valve to make a compact pilot operated pressure regulator as shown above. All Wizards are normally supplied with an operating medium air set which filters and reduces supply pressure of 25 to 250 psi to constant pressure of 20 psi for 3 to 15 psi, or 35 psi for 6 to 30 psi operation.

SURFACE MOUNTING

The Wizard can be mounted on the surface of a wall or any stable surface. A special mounting bracket is provided and any type of screw or bolt suitable for the mounting surface may be used.



FLUSH MOUNTING

By turning the bracket around that is provided for surface mounting, any Wizard can be mounted flush to a panel.

WORLD LEADER IN RESEARCH FOR BETTER PRESSURE AND LIQUID LEVEL CONTROL

For closer control in today's more complex processing industries

FISHER®

WIZARD II PRESSURE CONTROLLER

For over a quarter century, the name "Wizard" has become a byword as the pressure controller that is accurate, dependable and simple to operate in all types of industry.

Now, the WIZARD II takes over to meet the demands of modern, complex control systems requiring closer control. The WIZARD II retains all of the basic simplicity, accuracy and dependability of the Wizard 4100U, plus a number of new components. The WIZARD II is in a waterproof aluminum die-cast case and cover with ¼" tapped vent for gas service. With the addition of a few parts, the basic proportional controller can be converted to: (1) two-position action or "Snap Action", (2) pressure transmitter, (3) controller with remote set adjustment, (4) proportional plus reset response. The WIZARD II can be changed from direct to reverse action or vice versa without additional parts.

The superior subassembly construction stresses simplicity and compactness. Each subassembly is assembled and calibrated prior to mounting in the case. All Series 4150 Wizards can be supplied for remote set adjustment for changing the pressure setting from a location away from the Wizard controller.

Careful and exhaustive tests have conclusively proved that the WIZARD II measures up to the rigid Fisher standards.

A completely descriptive and illustrated bulletin on the WIZARD II is yours for the asking. Write today for Bulletin No. D-4150.

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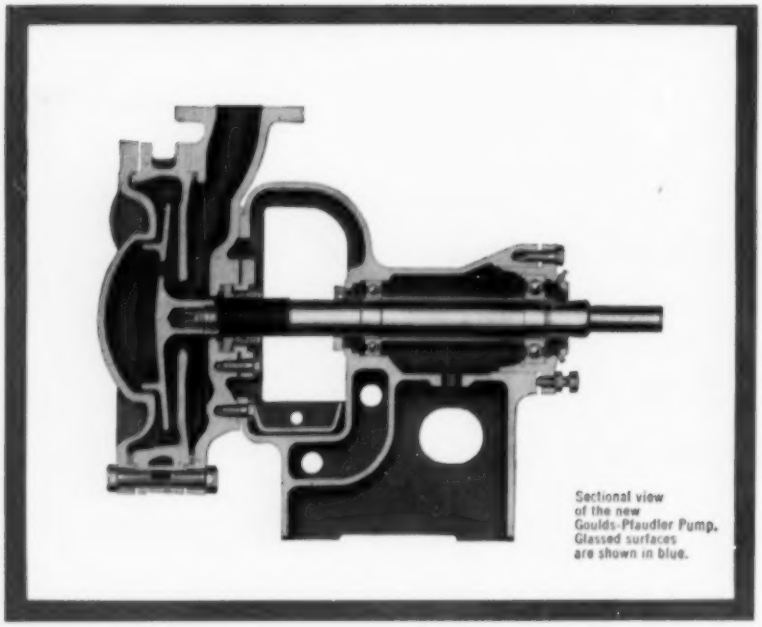
FISHER® Controls
SINCE 1880



Sectional view of the new Goulds-Pfaudler Pump. Glassed surfaces are shown in blue.

...pump corrosives in glass

New Goulds-Pfaudler glassed pump handles acids, alkalies for years... costs less than you may be paying now

Here's a centrifugal pump that lasts *for years* handling the most corrosive chemicals.

All liquid-contacting parts on this new Goulds-Pfaudler pump are glassed. This glass is resistant to all acids except hydrofluoric up to 212° F. and higher in many cases, as well as to many mild alkaline solutions.

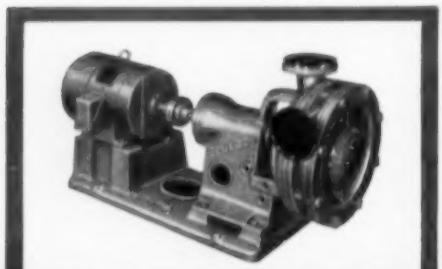
Besides getting superior corrosion resistance, you can handle sticky materials better, too, with the Goulds-Pfaudler glassed pump. Many plastics and synthetic rubbers and other materials that cling to metal, flow smoothly through this new pump.

Tough glass-metal surface

The glassed surfaces are tough—the powerful mechanical and chemical interlocking of the glass and metal provides an inseparable bond—the glass can't crack or shatter!

Most important, the Goulds-Pfaudler glassed pump costs less than you might think; less for example, than some special-alloy pumps. If you're pumping corrosives, this new pump's high efficiency and long life are almost sure to bring you substantial savings.

Four sizes offer capacities to 700 GPM, heads to 140 ft. For complete information, send now for Bulletin 725.2.



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About our authors

Governor Theodore McKeldin of Maryland, who heads the list of *CEP* authors this month, delivered the address from which we quote at the Baltimore National Meeting banquet of A.I.Ch.E. last month. Widely described as "spellbinding" by chemical engineers and their wives who heard his talk, the Governor's forceful delivery added much to the pungency of his remarks.

James C. DeHaven, who writes this month a critique on Government R & D contract administration policies, is by no means a newcomer to the field. As assistant to the president for Research of The Rand Corporation (Santa Monica, Calif.), he administers research projects which are conducted with the Corporation's own funds on subjects important to the national security and public welfare. He was formerly deputy chief of staff for development, HQ USAF, and assistant to the director of Battelle. Typical other projects under his guidance at Rand are a reappraisal of beryllium as an aircraft structural material and a survey of the technology and economics of water supply.

De Haven

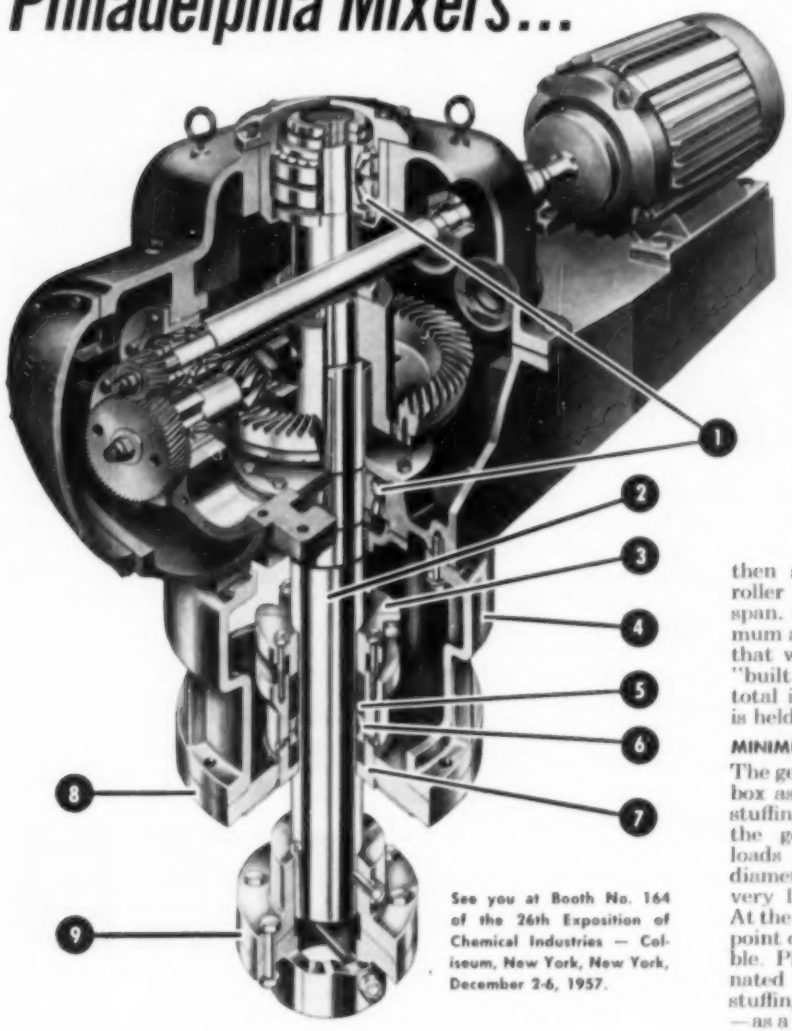
Gropper

Fred Gropper is group supervisor in DuPont's Industrial Engineering Section, Engineering Department. The I.E. Section is a consulting organization, in the sense that Gropper's activities take him (and his staff members) throughout DuPont's plants. After having developed a strong interest in I.E. in college, Gropper served in mechanical development, construction, and maintenance engineering before beginning to make a career out of I.E. During the war, he taught I.E. at various industrial plants as part of the speed-up for the war effort.

Bruce L. Cusack, now with Ground Systems Division of Hughes Aircraft, was formerly head of the Human Engineering Section at New York University. Cusack describes this as the first human engineering systems research laboratory ever operated. This classified work was done in N.Y.U.'s College of Engineering under Office

(Continued on page 36)

Philadelphia Mixers...



See you at Booth No. 164 of the 26th Exposition of Chemical Industries — Coliseum, New York, New York, December 2-6, 1957.

1. Generously sized bearings positioned with maximum span provide shaft operation of best precision.
2. Extremely rigid, large diameter, polished shafting deflects minimum amount under operating conditions. Ideal conditions are provided for best stuffing box life, lowest maintenance cost.
3. Gland follower designed for easy adjustment. Split feature makes it easy to repack stuffing box.
4. Rigid cast stand assures precision alignment of output shaft through stuffing box by means of rabbet fits to gear reducer base and mixer mounting flange. Stand design makes it easy to reach stuffing box gland for adjustment.
5. Standard square packing—readily available.
6. Lantern ring, with two lubrication fittings at 180°, provides opportunity for best stuffing box lubrication. Tapped lifting holes make removal easy.
7. Stuffing box hub, flange facing, mixer drive output shaft, and mixer coupling supplied in any machinable alloy required to suit process conditions.
8. Mounting flange provided to mate with ASA standard and other flange sizes.
9. Philadelphia Mixer coupling saves you field assembly cost by enabling us to completely assemble and test the drive unit at our plant. You simply bolt the mounting flange to your tank flange, then couple the lower agitator staff.

guarantee low cost, trouble-free stuffing box operation

Philadelphia Model PTS Mixers are designed and built with this principle in mind: *a stuffing box operates best on a shaft that runs best.* Every effort is exerted to provide each drive with a mixer shaft that runs absolutely true. As a result, Philadelphia Mixers guarantee top stuffing box performance with minimum maintenance . . . least downtime.

LESS SHAFT RUNOUT . . .

On each Philadelphia Mixer, great care is taken to hold shaft runout to a minimum. Output shafts are precisely machined, ground, and polished to smooth concentricity, then supported by large, high capacity roller bearings mounted with generous span. Bearing clearances are held to minimum allowable limits. The result is a shaft that will operate with absolute minimum "built-in" runout. Even in biggest units, total indicated runout at the stuffing box is held to as little as 0.002".

MINIMUM DEFLECTION . . . LESS MAINTENANCE

The gear reducer support stand and stuffing box assembly are designed to position the stuffing box just as close as possible beneath the gear reducer bearings. Unbalanced loads applied to extremely rigid, large diameter shafts by mixing impellers cause very little shaft deflection at any point. At the stuffing box, positioned so near to the point of shaft support, deflection is negligible. Philadelphia Mixer design has eliminated the need of shaft support from the stuffing box, and it can function as intended —as a shaft seal only! Operate at high tank pressures with extremely long overhung shafts . . . and still be assured of trouble-free operation with minimum maintenance.

WIDE RANGE OF PRESSURES AND TEMPERATURES . . .

The standard stuffing box shown is designed to operate with vessel pressures ranging from full vacuum to 150 psig, temperatures to 500°F and above—depending upon effective range of packing type required for process conditions. Cooled stuffing boxes are supplied where needed. Standard PTS assemblies are supplied mounted upon ASA 150 lb. standard raised face flanges. Flanges of other dimensions, or rated for higher pressures, can be supplied.

For further details, write, wire or phone your nearest Philadelphia Mixer representative.

philadelphia mixers

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INDUSTRIAL GEARS & SPEED REDUCERS • LIMITORQUE VALVE CONTROLS • FLUID MIXERS • FLEXIBLE COUPLINGS

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be sure

you match pumping

Efficiency

to the job...

Maximum head and delivery as compared to power consumed are the big factors in pumping efficiency. So regardless of the type of pumping job you have, you want a unit that gives the best results. You can't go wrong when you specify an Ingersoll-Rand Motorpump . . . available in a wide range of models from ¼ through 75 horsepower . . . capacities to 2800 gallons per minute . . . heads to 650 feet.

Motorpumps are compact, easy to install units with a versatility of mounting positions. Full details on I-R Motorpumps will be furnished promptly by your nearby Ingersoll-Rand branch office, or write direct for the latest catalog.

MOTORPUMP

by

Ingersoll-Rand

11 Broadway, New York 4, N.Y.

About our authors

(Continued from page 34)

of Naval Research sponsorship under the code name "Cadillac Project."

James Donovan, who with **Arne Gudheim** authored the article describing a new item of processing equipment, is well known to *CEP* readers. One of his most recent acts of service to the profession was his general chairmanship of the Boston Annual Meeting of A.I.Ch.E. Widely known in the Boston area as an entrepreneur in new process equipment development, Jim is president of his own equipment designing and building firm. Mr. Gudheim is president of Kontro Company, which is affiliated with Artisan Metal Products, Mr. Donovan's firm.

T. A. Sheets is staff assistant in the Research Department of the Electro Chemicals Division of Diamond Alkali Company. Having studied both chemical engineering and management subjects, Mr. Sheets is concerned primarily with marketing and the introduction and exploitation of new products, also takes the pulse of the older ones.

Sheets

Dougherty

Zievers

Charles F. Dougherty is manager, processing, of the Technical Development Branch at Air Force Plant 66 near McGregor, Texas. Prior to joining the Rocket Fuels Division of Phillips Petroleum (operator of the Air Force plant), Dougherty was process design and development engineer and later coordination and analysis engineer in the gasoline department of Phillips at Bartlesville. He was previously with Mid Continent and DuPont.

James F. Zievers, Walter L. Werchun, and **Richard W. Crain** are with Industrial Filter & Pump Company, Mr. Zievers being director of research and development. Werchun was a professor of thermodynamics at the University of Lwow (Poland) and later a lecturer at Polish University College in London before joining Industrial. Crain is director of laboratory test work.

(Continued on page 38)

Researchers:

Lithium Corporation INVITES YOU TO EXPLORE THE POSSIBILITIES OF LITHIUM COMPOUNDS AS POLYMERIZATION CATALYSTS

Lithium metal, lithium hydride, lithium hydroxide and lithium carbonate are the basis for both experimental and commercial studies as polymerization catalysts in the manufacture of certain plastics, polymers and resins. The polymerization reactions may be "addition" or "condensation" processes.

This new research tool has tremendous potential. The use of lithium metal as a catalyst for the polymerization of diolefins has been known for many years. By contrast, lithium metal dispersions were only recently used to polymerize isoprene to a "natural" rubber.

Lithium carbonate, to cite another example, is a preferred catalyst for the esterification of tall oils. Again, lithium hydroxide has been found to be a superior catalyst for the manufacture of alkyd resins. And work has been done with lithium hydride for ester interchange reactions.

In case you have a catalyst problem in mind requiring the use of highly reactive lithium, our PR&D department is making available information on this new and highly valuable research tool. Describe your application or request general information.

... trends ahead in industrial applications for lithium

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Letters to the editor

More on "Brainstorming"

Mr. McGriff's letter in the June issue of *CEP* (p. 14) is interesting but I cannot believe that the publication channel he proposes has a place in your magazine.

If *CEP* did add such a feature, you might be swamped and a great deal of careful sifting would have to be done before legitimate items of interest could be separated and published.

Free advertising is always wanted.

Crack Pots Unlimited are incorporated in every state in the U.S.A.

Ideas on what to do and how to do it are a dime a dozen as long as they are not tied to factual limits of proven engineering and economic feasibility. Consultants are being approached continually by people with ideas, who think that the idea is worth 90% of the possible corporate picture and who walk out angrily when you mention the cost of development, manufacture, and marketing.

The question of ideas reminds me of the idea which the famous dancer, Isadora Duncan, had when she visited Bernard Shaw and proposed that they become the parents of a child having his brain and her body and Shaw said, "suppose it has your brain and my body?"

Contrary to popular opinion, much more progress comes from sound scientific analysis than from brainstorms or bull sessions (remember them?). Newton's apple received the publicity, but I would bet money that, in his time, Newton used it as an example rather than an inspiration.

We are living in a commercial age and your relations with the members of A.I.Ch.E., your subscribers, and your advertisers are commercial. I can only see trouble if you or anyone else engaged in a publishing activity which might obscure the ownership of a basic idea or the development of a product.

Most of your readers will prefer reports in technical magazines, the wealth of information in our libraries, discussions with their friends, or the services of a consultant to evaluate their ideas.

H. Leslie Bullock
New York, N. Y.

Reader Bullock raises some interesting points that deserve reply. With regard to being swamped by a great deal of material that would have to be carefully sifted, this is not unusual. Actually, the purpose of an "outlet for brainstorms" would be to increase the volume of such material. Granted, this makes work for editors. I am not sure that anyone knows just how such an idea could be handled, but I believe that Mr. McGriff's intentions were to start an experiment. If my deduction is correct, I believe that he feels that the chances for increasing the free flow of ideas of individuals might greatly outweigh the problems of sorting out the worthwhile from the rdiculous, the sincere from the promotional.

Mr. Bullock points out that we are living in a commercial age. Of course, this is true. But are we not in danger of resigning ourselves to this condition at a time when we look upon it as perhaps a factor of annoyance. We may yet realize that by not taking a step like Mr. McGriff's, or perhaps whatever ideas others may come up with, we may be losing good opportunities for stimulating the strictly personal point of view.

The editor has considerable doubt that Mr. Bullock is writing under any harness of organizational restraint. Perhaps Mr. McGriff has already scored an important point by having stimulated Mr. Bullock to let us have his interesting views.—Editor.

Barnstorming Brainstorms

You have hit upon one of the most fascinating ideas in many a moon in your June, 1957, issue (page 14). The suggestion by Stuart G. McGriff that your magazine or some magazine commence an "Outlet for Brainstorms" sounds like a fine idea.

Very few things have hit the industrial and scientific world with such impact as Dr. Osborne's ideas for "brainstorming." It seems that practically all levels of scientific people and industrial management are ready to accept this technique. There is really no significant point in arguing whether Dr. Osborne or somebody else really invented the idea or if the idea is really new at all.

A column in which readers could express their "brainstorms" without the necessity of scientific proof and without any fear of criticism sounds like a project that *CEP* could do a fine job of—and without any harm to circulation either.

John E. Thompson
Chicago, Illinois

New Home

I am delighted to note that the United Engineering Trustees showed the courage and vision to buy a site for the new United Engineering Center on United Nations Plaza. Their action accomplishes many of the objectives that led a number of us to advocate Washington as a particularly appropriate place for the Center.

If the architectural conception for the building shows the same vision, I think we will see real enthusiasm develop for the building fund drive.

Through their works, engineers have erected monuments to individual genius around the globe. I hope the Center can be made an equally expressive architectural symbol of the technical integrity and imagination that characterize the higher achievements of the profession.

DeWitt O. Myatt
Alexandria, Virginia

About our authors

(Continued from page 36)

L. A. Lundberg is a member of the firm of A. H. Lundberg, Inc. of Mercer Island, Washington. The firm specializes in the engineering of pulp mill equipment as well as selling such equipment as manufacturers' agents. It was in this connection that author Lundberg spent all of 1953 in Sweden working with A. B. Kamyr on their continuous pulping process prior to their making this equipment available in the United States.

A. L. Fuller, Arthur L. Kohl, and **Ernest Butcher** are with the Fluor organization. Fuller is in charge of the cooling tower research program and Kohl is head of the chemical engineering section of the parent Fluor organization. Butcher was chief development engineer for Fluor Products Company at the time of writing of the article appearing in this issue. He is now selling Fluor products in Mexico City.

Joseph E. Burghardt, who reveals to chemical engineers the propulsion makeup of the Vanguard space satellite, is in a position to have broad knowledge about this project. He coordinates the activities of Martin Company engineers dealing with propulsion and aerodynamics. A "Martin man" for almost 20 years, the first time he actually had a chance to see a large rocket fired was last December, when the initial test vehicle for Project Vanguard was launched successfully.

Fuller

Kohl

Burghardt

News from
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Division of Union Carbide Corporation · 30 East 42nd Street, New York 17, N. Y.
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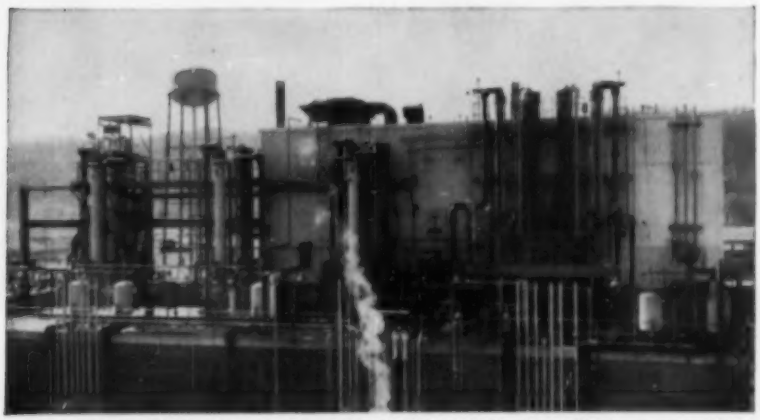
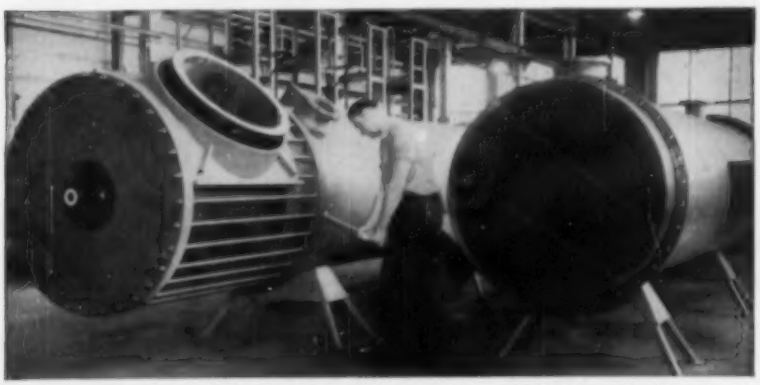
"KARBATE" IMPERVIOUS GRAPHITE SHELL AND TUBE HEAT EXCHANGERS PROVE THEIR ECONOMY IN COOLING CORROSIVE GASES

Gas coolers of "Karbate" Impervious Graphite cost less and last longer than coolers made of less corrosion-resistant materials.



Ten "Karbate" Impervious Graphite Shell And Tube Heat Exchangers cooling and condensing mixtures of organic vapors and hydrogen chloride. Units are arranged in pairs—uninsulated unit in each pair has plant cooling water on shell side; insulated unit is refrigerated.



These standard "Karbate" heat exchangers have 685-⅞" I. D. "Karbate" tubes assembled between "Karbate" tube sheets in 45" diameter steel shells. Corrosive water-saturated sulfur dioxide gas, which contains considerable entrained sulfuric acid, will enter and leave tube sides through 24" diameter connections on "Haveg" phenolic resin covers.

National Carbon provides complete Technical Service—An experienced technical staff designs and rates "Karbate" Shell and Tube Heat Exchangers manufactured and guaranteed by National Carbon. Dr. D. Q. Kern, well-known consultant and author of PROCESS HEAT TRANSFER, serves as an advisor to this group.

Particularly significant today is the economical cooling of corrosive gases. "Karbate" Impervious Graphite Heat Exchangers have the corrosion resistance, high thermal conductivity, immunity to thermal shock, and moderate cost vital to this service.

For cooling corrosive gases, "Karbate" Exchangers operate either horizontally or vertically, usually with the corrosive gas inside the "Karbate" tubes and with the coolant in the steel shell. These exchangers are furnished with shells of "Haveg" phenolic resin, impervious graphite, rubber or glass-lined steel for operation with corrosive gas on the outside of the "Karbate" tubes.

A complete line of "Karbate" Heat Exchangers is available in sixteen shell sizes from 6" I.D. to 45" I.D. with tube lengths of 6', 9', 12', 14', and 16'. Standard components are carried in stock for immediate assembly of units having up to 3585 sq. ft. of heat transfer surface.

For full details, request **Catalog Section S-6800NL**

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UNION CARBIDE

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unequaled –

Simplest installation — orifice flange tap connections at standard spacing, are provided at both ends.

Drain and vent holes at lowest and highest points on both sides.

Purged cover protects transmitter from weather, dust, and fumes.

Over 60,000 now in use!

No zero drift . . . positive overrange protection . . . high sustained accuracy even under the most punishing operating conditions. No wonder over 60,000 Foxboro d/p Cell Transmitters have been installed since they were introduced in 1948.

By introducing the modern concept of high speed flow measurement and control, these differential pressure transmitters have *revolutionized* many an industrial process. Bulletin 13-11A shows how — and portrays the benefits the d/p Cell Transmitter offers you. Write **The Foxboro Company, 9310 Neponset Ave., Foxboro, Mass., U.S.A.**

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FIRST in Flow Measurement and Control

FLOW TRANSMITTERS...

in accuracy, stability and performance

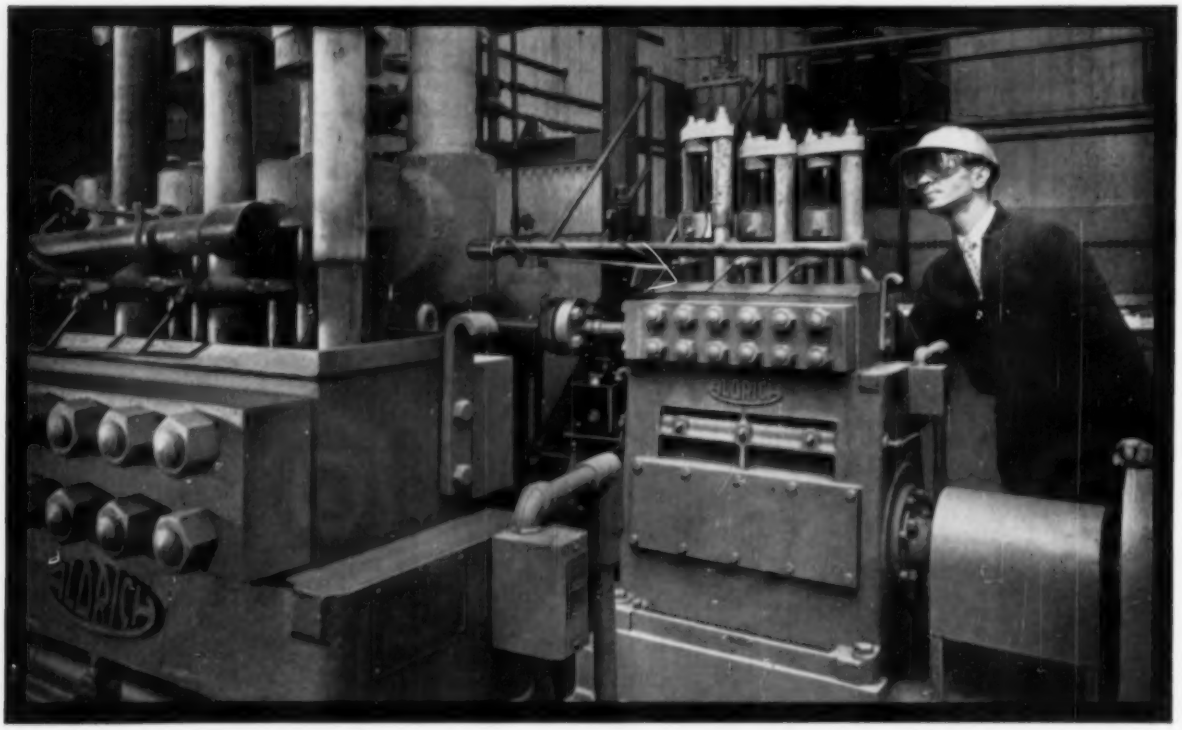
All-metal construction: body of 316 stainless or rustproofed carbon steel. New self-damping, stainless steel measuring element.

Fully adjustable ranges: from 0-20" to 0-250"; and 0-200" to 0-850" water differential. Calibrated accuracy ±½%.

SPENCER CHEMICAL CO. UNRAVELS KNOTTY PROBLEM:

Maintaining a controlled flow of liquid ammonia at high pressures, 24 hours a day.

At the Vicksburg, Miss. plant of Spencer Chemical Company, ammonia production demands two things of pumps: (1) 24-hour, 7-day-week operation and (2) continuous flow of controlled volumes of liquid ammonia at high pressure.



How Spencer licked the problem: When Spencer began outlining construction plans in 1951, company engineers specified two Aldrich Direct Flow, ¾" x 3" stroke Triplex Pumps. These were scheduled to be used for alternate 30-day periods. According to company spokesmen, nearly four years of service have proved these pumps to be efficient and capable of durable service.

Results: Dependability and freedom from trouble in all phases of operation. The Vicksburg Works Maintenance Superintendent tells us: "The Aldrich Pump is an excellent unit. Valve life is excellent and packing life exceptionally good."

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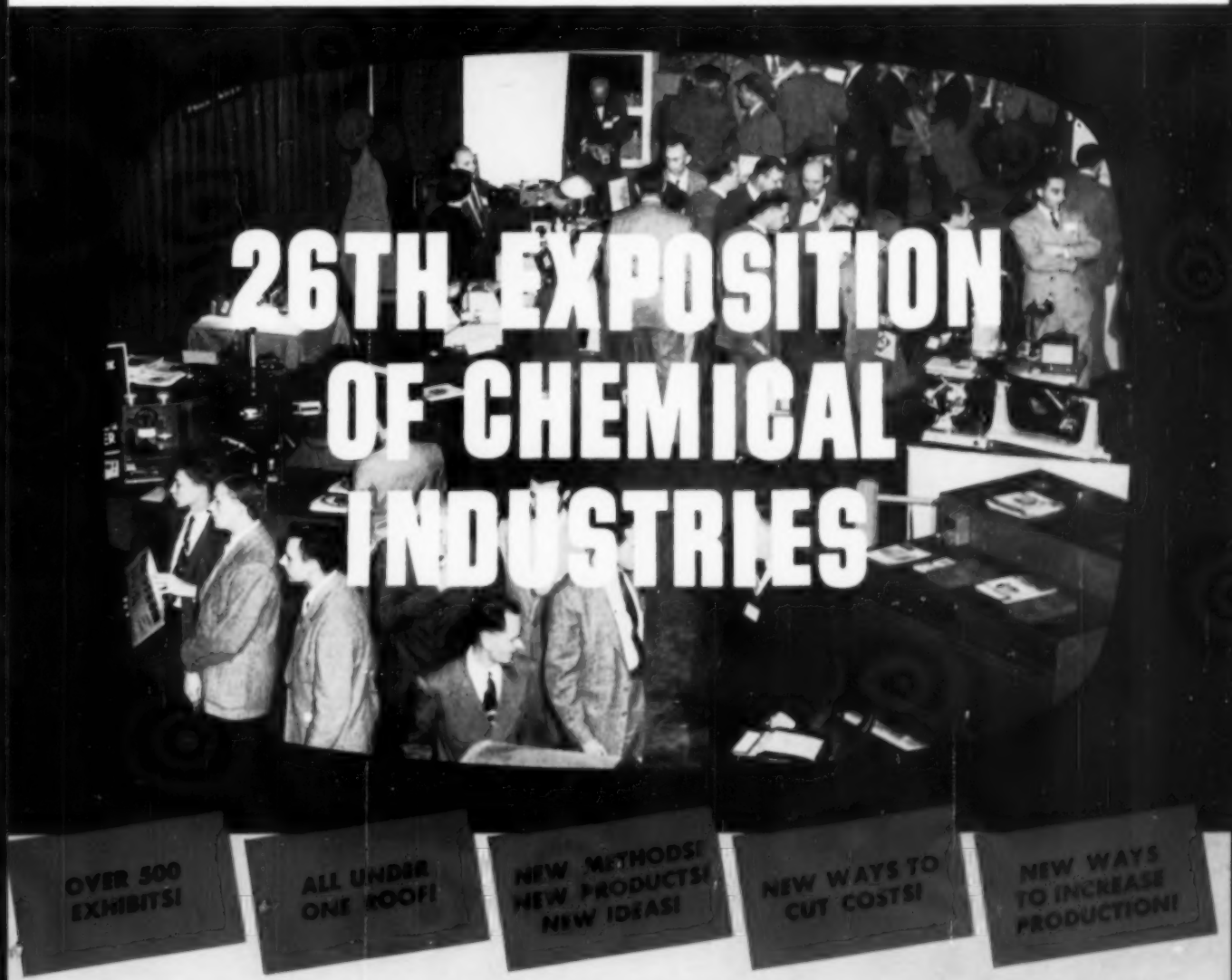
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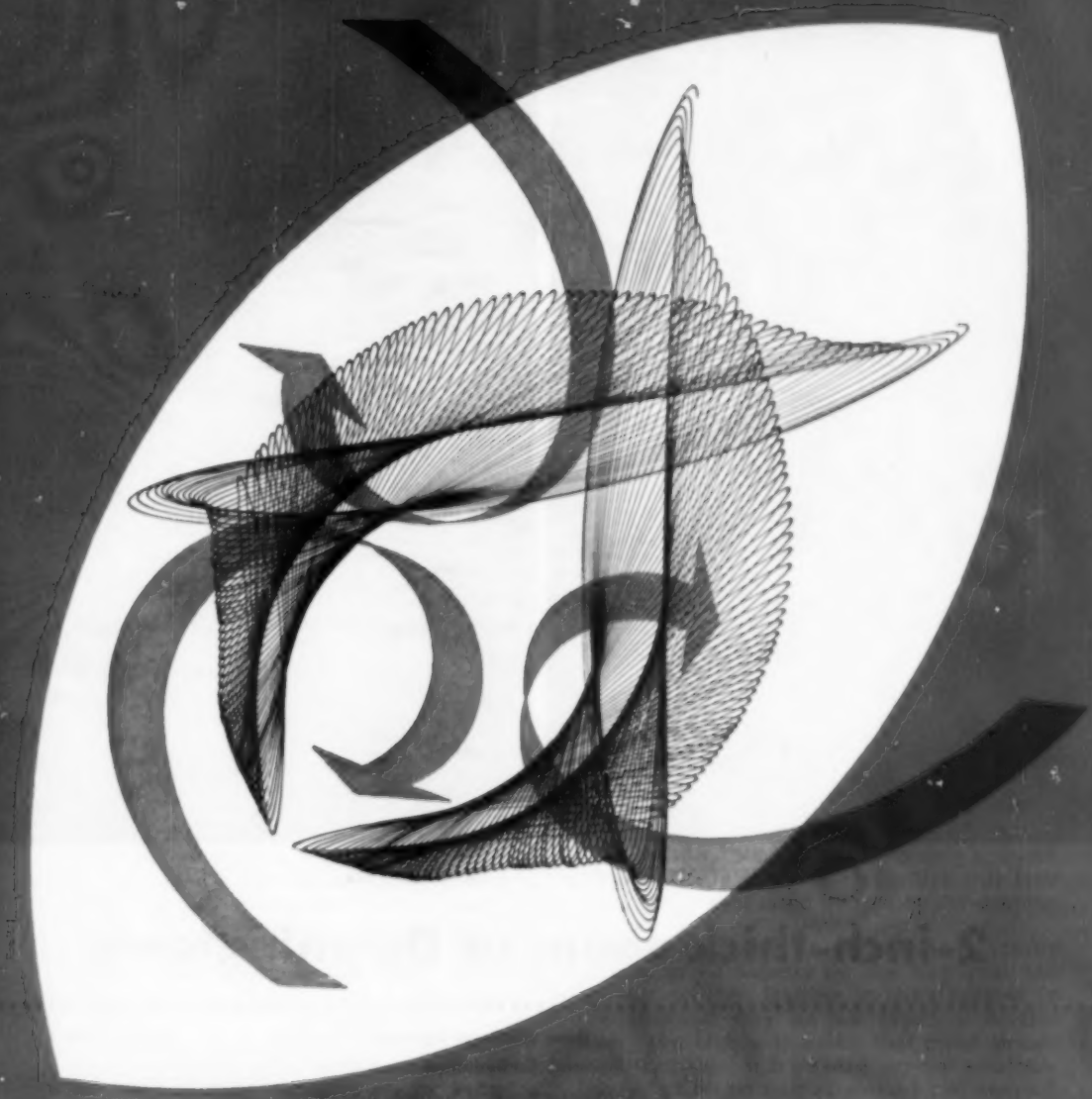

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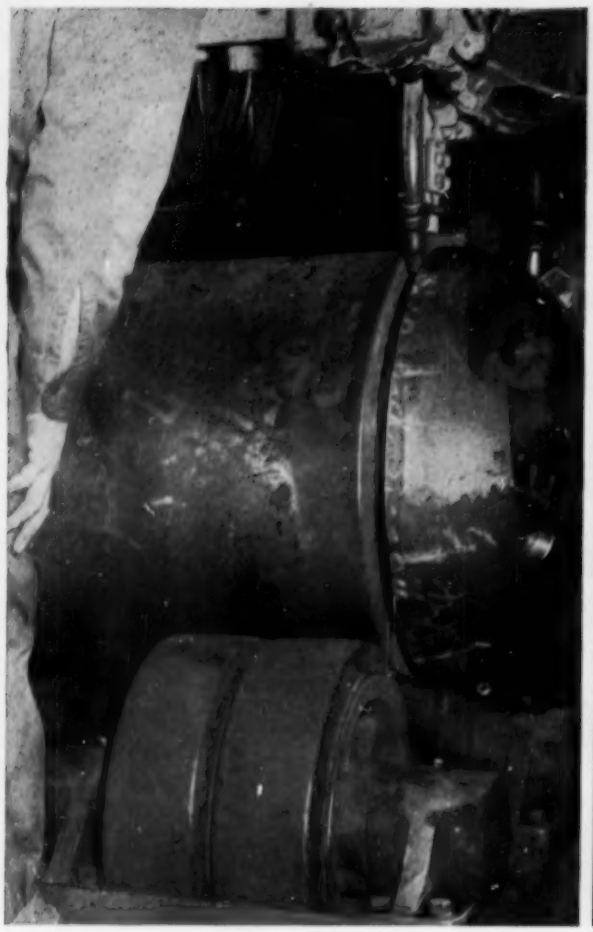

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Now that Labor Day has come and gone, the expected autumn business upturn has not developed to any encouraging extent. The chemical business ran on a fairly even keel during the first nine months of the year, with sales up moderately and earnings (generally speaking) down. Sales actually did not show gains commensurate with increased plant capacity in many lines. Business leaders were hopefully looking to a fall upturn in general business to help out in the final months of the year, but it now looks more and more as if no spectacular upturn will develop.

There has been a slight increase in home building and in automobile production and some improvement in steel buying, but no real upsurge. The textile industry, an important consumer of chemicals, has failed to show any gains so far this fall and buying still seems to be on a hand-to-mouth basis. The same is true of the rayon industry, although sales of synthetic fibers are going well.

Signs are appearing that all is not well in the paper industry with the announcement of cutbacks in production of newsprint in Canada and in Finland. Inventories of oil have been mounting with the result that there has been a cutback in permissable oil production in Texas in October with wells restricted to 12 days' operation per month.

Chemical prices have been holding well and there have been a number of advances, notably in ammonia and ammonium nitrate, and it is probable that the industry, suffering from the long present "cost-price" squeeze, will endeavor to raise other prices slowly when it seems feasible.

Price Cutting

There have been a few signs however, that all is not well in some segments of the industry. There have been reliable reports, not officially confirmed, of undercover price cutting in polyethylene and polystyrene as the result of a squabble between two big firms in the field.

The sudden and unexpected price cut of $3 a ton made by Texas Gulf Sulphur caught other sulfur producers by surprise and stirred up some hard feelings in the industry. Jefferson Lake Sulphur apparently was especially annoyed because the company was obliged to call off a projected stock offering as a result of the decline in the price of its stock on the N.Y. Stock Exchange.

This is the first drop in the price of sulfur since 1937. The reason for the cut was probably the increasing competition from the relatively new Mexican producers. Texas Gulf's own inventory went up 600,000 tons, the first real gain since the end of the last war. Stocks of all producers at the end of May increased about 800,000 tons to over 4,000,000 tons, which is concrete evidence of stock-piling which the Federal Reserve Bank has been viewing with alarm.

Outside the chemical industry there have been other important price declines. Copper prices continued to decline, hitting 25 cents a pound, but with no signs of any important curtailment in production as yet.

A price war has broken out in certain fabricated aluminum products. Stocks of aluminum in the hands of producers rose to 193,000 tons at midyear against stocks of only about 12,000 a year previous. Meanwhile, the aluminum industry is going ahead with construction which will add substantially to capacity by the end of next year.

The Long Pull

The stock market, usually believed to be a barometer of the business outlook, continued to decline sharply in September. The Wall Street fraternity, which does not necessarily guess the shape of things to come any better than anyone else, continues to feel that many stocks are still high in relation to earnings. There has, however, been no indication of any heavy selling by major investors such as investment trusts, pension funds, and insurance companies. The men who guide the affairs of these funds take the somewhat paradoxical viewpoint that this is not really a "bear market," but only a drastic setback in a long bull market which will later resume its upward trend spurred by the creeping inflation.

Meanwhile, leaders in the chemical industry continue to be hopeful for the long pull and look for another increase in sales volume in 1958 although they do not expect a notable jump. The feeling is strong that prices should go up next year. It is pointed out that wholesale chemical prices are only up about 9 per cent over the 1947-1949 average, whereas the prices of all manufactured goods are up about 17 per cent from the base period. Reflecting this, the profit margins of eight of the largest chemical companies declined 10 per cent in 1956 and were down another 14 per cent in first half 1957.

The expansion program of the chemical industry continues unabated. It is estimated that the whole industry will spend about $1,800,000,000 this year. A check with some of the largest firms indicates that they will spend more in 1958 than their record high expenditures in 1957. Dow Chemical, for example, will spend about $175 million next year on new plants against $162 million in its May 1957 fiscal year. Union Carbide, which is spending $180 million in 1957, is currently planning to spend substantially more than this in 1958. Allied Chemical & Dye Corp. is planning to spend as much next year as its $70 million expansion costs in 1957.

Guide to better pump selection

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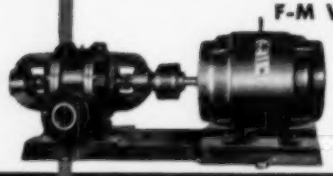
boiler feed condensate return hot and cold liquids chemicals refrigerants, etc.	up to 200 gpm. pressures to 900 ft.	 **F-M WESTCO PERIPHERAL PUMPS** High pressure at normal operating speeds. Handle widely varying heads with little change in capacity. Sizes 1¼" through 2½".
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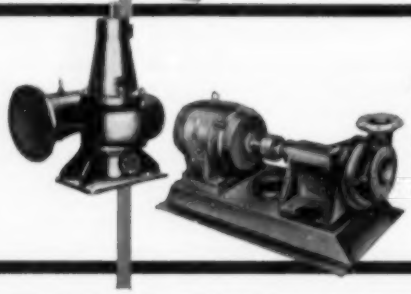
hot and cold liquids chemicals circulating liquids nonviscous liquids cooling towers condenser circulation, etc.	up to 100,000 gpm. pressures to 250 ft.	 **F-M END-SUCTION PUMPS** A wide line of rugged, precision-built pumps. Sizes ¾" through 54". Horizontal or vertical centrifugal.

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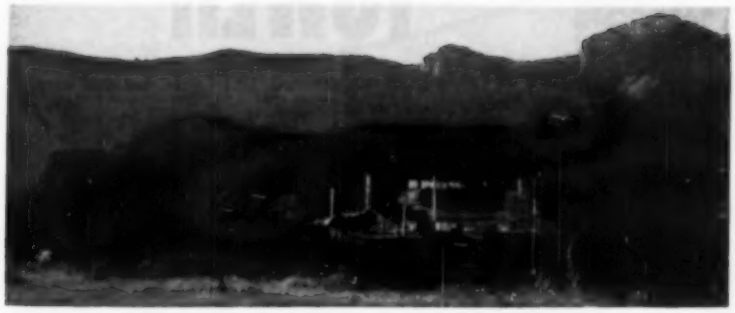

Rifle Training

In a snug valley at the foot of an oil shale precipice in the Colorado Rockies lies a government chemical engineering facility apparently in the final stages of abandonment. This integrated series of units (including rock mining, crushing, retorting, oil refining, process control, and administration, plus a housing development of seventy cottages) is the Bureau of Mines Rifle Shale Oil Experiment Station, closed in June 1956 after long debate and consideration of development plans by commercial groups.

That Rifle would appear to be in its last throes is indicated by debate in the recent session of Congress on the question of continuation of funds for maintaining Rifle on even a standby basis. In general, the Senate appeared to favor Rifle's continuation, while the House seemed to prefer the economy of total abandonment. Thus, unless some new idea comes along that can inspire the necessary support for continuance, the facility is likely to be added to the list of Western ghost towns.

One suggestion for taking advantage of the sizeable Rifle investment is that it be used in the training of selected chemical engineering students in practical aspects of their profession—a facility managed by competent educators and under the supervision of recognized educational establishments. Funds for this could be Federal, in which case the National Science Foundation could presumably assume overall supervision. Rifle might thus become either a useful practice school for undergraduates, or, with a curriculum pegged between the senior year and the first year of graduate training, as a valuable introduction to graduate study. Or it might be used during winter months to train young chemical engineers from industry and from foreign nations.

The scheme would appear to have other attractive qualities. Rifle's scenic location provides a stimulating atmosphere in which to work. The tightly integrated community would encourage close acquaintanceship between students and instructing staff. The rock processing portion of the training experience would undoubtedly be particularly constructive and valuable, particularly to those mineral processing industries which need increasing numbers of chemical engineers to contribute importantly to process development. Above all, this use of the Rifle plant might well answer a question which will sooner or later have to be answered—can we as a nation any longer afford the luxury of such abandoned monuments as Rifle threatens to become when we are striving by so many other means to stimulate the interest and improve the training of qualified young people in the exciting profession of chemical engineering?

—J.B.M.

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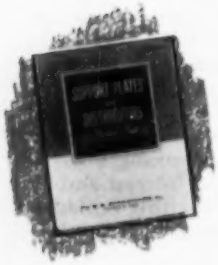

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direct operating labor costs

can be an important part of the total cost of manufacture, even of chemicals. To put this and other cost factors into the perspective of actual management experience, here is an analysis by Carl F. Prutton:

The chemical industry is based upon three basic assets: scientific and technical knowledge; manpower of several types and skills; and adequate financial support. In preparing for the next several decades of accelerated growth and increased responsibilities, the industry must carefully examine ways and means by which each of these important foundations can be adequately strengthened, or it will be unable to realize fully its opportunities in the years ahead.

The annual rate of growth of the industry is several times the average rate of growth of U.S. industry as a whole: it should quadruple in size by 1980—a mere twenty-three years ahead.

Such an expansion program will require many billions of dollars of new capital; will require vast numbers of skilled men and capable leaders; and will tax to the limit the industry's accumulation of fundamental scientific and technical knowledge.

Manpower

As the chemical industry expands and increases the complexity of its products and processes, it is obvious that it will have need of increasing numbers of capable personnel with a wide range of background and training. Men with technical and scientific training and experience will be required in ever-greater numbers for management, production, engineering, research, and sales. The number and percentage of technically or scientifically trained men who are involved in the management of the American chemical industry have gradually increased and this increase will probably continue. Creating new and more complex chemical products and processes of the future will obviously require highly skilled and trained personnel. The chemical industry's customers will need, and should be encouraged to acquire, adequate numbers of men

skilled in the application of chemical products. Dealing with such personnel will require sales and technical service forces with full chemical training and background.

To be certain that the world makes maximum use of chemical products, chemically trained personnel must be fully available not only for the chemical industry, but for other industries—in agriculture, in medicine, in government, and in educational institutions.

In production, as the industry moves toward the more fully automated chemical plant, progress may be retarded by a lack of highly capable technologists. Such men will be needed, not only for control and operation of these new units, but also for the supervision of a relatively small labor force comprised mainly of highly skilled technicians, with a minimum of labor of lesser skills.

The chemical industry has in recent years made major strides in an organized manner to point out to promising young people the interesting and challenging aspects of a career based upon the physical sciences—particularly in the chemical industry. Such a program of encouragement and initial inspiration must be backed up fully by three important moves by each major employer of technically trained personnel.

1. *Technically trained people must be given real opportunities for growth and advancement* into positions of major responsibility in the industry. Such advancement opportunities should include the correct climate and, if necessary, auxiliary training, so that qualified technical personnel can advance into the highest ranks of management.

2. *They must receive adequate tangible and intangible rewards* for their constructive services and achievements.

3. *While employed in technical matters, they must not be assigned to routine tasks* which can be performed by technicians or men of lower training or experience.

To reward properly or to advance outstanding men requires careful and continuous analysis of their performance and potentials by management. This assignment of major responsibilities to the proper men, and then allotting them adequate rewards for their superior efforts through economic return and through recognition and advancement, are among the most important decisions to be made by top management. It is important that employers do not treat technical personnel as a uniform group, or similar to the treatment given to and demanded by organized labor. They must be recognized as individual, professional employees entitled to individual consideration and treatment.

Basic Knowledge

The basic laws and data available today in the physical sciences have been derived largely through the efforts of scientists over the past century and more. However, application of these principles in industry at an ever-increasing rate has come only in recent decades. A strong industry has been built upon this foundation, so it now becomes a prime responsibility of that industry to aid and encourage the replenishment and growth of basic scientific knowledge. Such support is essential to the future growth and stability of the industry.

The industry must encourage this program through economic grants, through advice and counsel, and through cooperation with educational institutions and their faculty members. Schools must be provided with the proper atmosphere and with the facilities required for the growth of basic science studies. Encouragement should be given to men of great talents to choose work in the basic sciences, rather than to be lured toward more commercial occupations where economic returns are great compared to the meager salaries now paid to most college faculty members. Industrial and governmental research laboratories must also assume a greater share in building up the fund of basic sciences. Approximately $300 million are now spent each year on basic science research in this country, and this appears wholly inadequate when compared with the total research cost of about six billion dollars.

Capital Needs

The chemical industry, expanding at a rate much faster than that of the average of all U.S. industry, therefore has capital needs much greater than the average of all U.S. industry. These capital needs are greatly increased by the fact that for every dollar of annual sales volume from chemical plants, about one dollar is expended for the construction of the plant facility. Here the industry is unique, since the average U.S. industry produces two dollars of sales volume annually for each dollar of capital invested in plants. This high use of capital in the industry adds to the difficulty in obtaining necessary capital.

Rather than attempting a detailed discussion of the many financial aspects of the chemical industry, let us consider a few simple but major facets of this serious problem, and particularly several areas where chemical engineers can and must make worthwhile contributions.

To improve this situation we find that there are several internal factors over which there is some control and these are mainly concerned with drastic improvements in *Return On Investment.*

Since: *Return on Investment* = $ *Profits* : $ *Invested Capital* = ($ *Profit*) ($ *Sales*) : ($ *Sales*) ($ *Capital Invested*), there are two important ratios to be considered, namely:

- $ *Profit* : $ *Sales*—which is largely dependent, internally at least, upon *Minimum Production Costs,* and

- $ *Sales* : $ *Capital*—which is dependent internally upon building plants *with minimum capital invested,* and *in operating plants at maximum economic rates.*

In addition to the above simple generalizations, it will be shown later that too low a ratio of Sales Dollars to Capital Dollars will increase production costs through high depreciation charges, particularly under the higher depreciation rates now possible in the early years.

Chemical engineers have two primary assignments, namely:

1. *Improving operating profit margins* to increase retained earnings, and to better justify confidence in investors in supplying necessary outside capital, and

2. *Improving the use of capital* by reducing cost of plants and by operating them at maximum economic rates.

Operating profits may be improved in many ways. One of the most obvious ways of obtaining reasonable operating profits is through maintenance of an adequate pricing policy. In general, the increase in prices of

chemical products has lagged far behind the increase in costs. Other commodities, such as steel, etc., have not shown such altruistic trends.

In such a cost-price squeeze period, we must do all within our power to reduce manufacturing costs in order that we may maintain reasonable profit levels.

One of the best methods of improving profits lies in operating plant facilities at maximum economic levels of output, with minimum downtime for maintenance or lowered production due to lack of sales. In most chemical plants, operation above design capacity may involve certain added costs and possibly lowered efficiencies, but to obtain maximum profit from a plant usually requires efficient and steady operation at these higher levels. At these higher rates, labor costs as well as overhead charges are lowered over the entire plant production. Maintenance and use of raw materials and utilities may increase somewhat. With most plants, the removal of bottlenecks after thorough study is an essential before these higher, more profitable levels of production can be fully realized.

Another area for significant profit improvement lies in reduction in manpower needs in chemical plants. Everyone appreciates the possibilities that lie in reduced labor costs through automation and automatically operated plants. However, in certain chemical plants making products where profit margins are low, salaried personnel must also be kept to an absolute minimum. Each plant manager wants to build up a well-rounded staff, no matter how small a plant he may have or what the economics of the business may be. Payment for salaried and hourly personnel is now about one-quarter of all our U.S. chemical production costs, and must be constantly surveyed as a major potential source of improved profits.

The improvement in usage of capital in the building of chemical plants is a second major area where chemical engineers can be of significant service to the industry. Such reduction will obviously lessen the industry's need for new capital for its future expansion.

Reduction in the use of capital in plant construction can have the following beneficial results:

- Reduce the amount of outside capital required.
- Reduce depreciation charges made against production costs which, with the sum-of-the digits method, are quite heavy in the early years of plant operation.
- Reduce financial risk in ventures involving new chemicals.

It has been mentioned that the ratio of Sales Dollars to Capital Dollars in the U.S. chemical industry is about one, while all U.S. industry averages about two dollars of annual sales per dollar of invested capital. There are two general ways in which the chemical industry's ratio may be increased:

1. Reduction of plant construction costs through economic engineering and through initial installation of simple processes.
2. Maximum economic production rate from a given plant facility.

Considering two extremes of this Sales Dollar : Capital Dollar ratio problem shows what impact high capital in plants has on profits, on competitive position, and on financial risks.

Example A is a plant where two dollars of capital are expended for each dollar of annual sales.

Example B is a plant (to produce the same product as Plant A) built for fifty cents for each dollar of annual sales. In each case depreciation is 10 per cent per year, and production costs, other than depreciation, are identical; also, investors want an after-tax profit of 10 per cent in keeping with the risks involved.

Carl F. Prutton, executive vice-president of Food Machinery & Chemical Company, is a well-known spokesman for the chemical industry. In the accompanying article, delivered before the recent Baltimore meeting of the A.I.Ch.E., he draws upon his many years of experience in the field to analyze some of the problems of the industry's continuing expansion.

I, *Production Cost (including Depreciation)* will be lower in Example B by ($2.00—.50) (.1) = *15 cents on every dollar of sales*, the difference in depreciation charges.

II, *Profit Margin Required to Produce 10 per cent Profit After Tax:*

Example A

.10(2.00) × 2 = before tax profit/$ sales = *40 cents*.

Example B

.10(.50) × 2 = before tax profit/$ sales = *10 cents*.

Therefore, in Example A, the added costs for capital and depreciation charges amount to (.40 + .20) − (.10 + .05) = 45 *cents*. In other words, the excessive use of capital in Example A has produced these harmful results:

1. Four times as much capital required, and financial risk in proportion.
2. A 45 per cent (on sales price) economic disadvantage against low capital (Example B) competitor.
3. If a company is the sole manufacturer of this new product with plant A, any outsider seeing an apparent profit margin of 45 per cent on sales would be attracted into the business.
4. It usually occurs that plant B will have a simpler process than A, and therefore have still lower production costs.

These widely divergent examples may seem exaggerated and are seldom encountered, but there have been several cases of this order of magnitude, and a multitude with somewhat lower differences.

It must be admitted, in certain well-standardized chemical plants, that only minor variations in this Sales Dollar: Capital Dollar ratio can be achieved. However, even in those cases, the ratio can be improved from 10 to 50 per cent or more, by operating at maximum economic production rates.

On new chemical plant construction, there are many ways in which design and operating engineers can

achieve low-cost new plants. Such efforts start back in the research laboratory or wherever the process originates. Sound engineering, both design and operating personnel, must be available to guide the process along lines of simplicity and economy. One of the most difficult decisions of management is to determine when a new process should be transferred from jurisdiction of the research group to that of men of greater commercial and technical and background skills. The insistence of a research organization in staying in control of a project until the finished plant is operating has produced some of the weirdest and most uneconomical plants encountered.

Capital Savings

In the actual engineering of a plant, there are many ways for the saving of capital:

- *Buildings can be reduced to a practical minimum.* Even in the colder parts of this country it is practical to house many process units outside a building. In many cases, it is the safest practice.

- *General facilities should be kept to a minimum,* except those essential facilities upon which economic, continuous plant operation depends, such as steam, power and water supply.

- *Spare units should be chosen with greatest care,* and it is not essential to have a spare for many units.

- *Before design and construction of specialized units, be certain that you have adequate process data and corrosion data* for such design. For costly units, large-scale pilot testing must be adequately and fully completed.

- *Even with standard equipment*—particularly for filtration, sedimentation, and drying—*one must be certain that optimum feed or operating conditions be known* for most economic design. Testing of construction materials for corrosion and abrasion must be fully completed or major costs may occur.

- *Key process units which require continuous operation, and which cannot be quickly or easily replaced, must be selected with greatest care and reasonable conservatism.* Some design engineers, who are easily swayed by manufacturers with new improved equipment, sometimes make major errors on such key equipment.

- *Never jam equipment too tightly together,* thus blocking easy access for repair, replacement, or addition of another unit for bottleneck removal.

- *Process equipment, where cost is low, should be given adequate safety factor in design.* Extra size does not cost much at the start, but will if it proves to be a bottleneck later.

- *Be certain to have the Sales Department involved deeply in decisions as to size of plant; types and specifications of products to be made; storage and shipping facilities.* However, top management must see that excessive or illogical demands are not made. Just as one sees plants which have been mis-designed by Research, one also sees unused facilities stipulated at one time as essential requirement for Sales.

- *Production management must be controlled to a reasonable degree in its demands for high-cost office buildings* and for capacity design factors far beyond the sound minimum.

DIRECT

Fred Gropper * | E. I. du Pont de Nemours & Company, Inc., Wilmington, Delaware

In the past twenty-five years the chemical industry has established itself as one of the truly basic industries in the nation's economy. In terms of total assets, the industry ranks fourth in the field of manufacturing, but more important, development and research in the industry and in its allied fields have been so farreaching that hardly a business exists today that does not look to the chemical field as an indispensable supplier. The one billion dollar annual expansion rate in the industry, accompanied by new products to meet new needs, promises to elevate the industry to first place in American living in the next few years.

In spite of its enviable position, the industry is not without competition. Natural fibers compete with man-made fibers; natural lubricants far outstrip artificial ones; natural rubber faces the challenge of synthetic elastomeric material; and leather, wood, and metals compete with plastics in thousands of applications. To competition from without is added stiff competition for the cutomer's approval within the industry itself.

The subject of direct operating labor costs therefore has extreme sig-

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LABOR COSTS: AN INTRODUCTION

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Increasing emphasis on automatic control of chemical processes has drawn attention to the problem of best disposition of operators—one which cannot be readily handled on the basis of experience with similar operations. Increasing demands of organized labor are also presenting problems which must be faced by management in assignment of appropriate tasks to plant operators.

There are many different approaches to the problem of labor estimation. Some are quite simple, such as the rule-of-thumb of one man for every eight instruments controlling a process, or the employment of a certain number of man-hours per unit product. Others involve, in some instances, satisfying Union demands for an appropriate number of operators and helpers. The problem of wage incentive plans and fringe benefits may also be considerations. In the articles on direct labor costs appearing in this and the next issue of *CEP*, the objective is to explore a few recognized procedures used by leading companies without in any way implying that there are any hard and fast rules involved.

Throughout these articles it will be noted that the idea keeps coming up that it is important to emphasize incentives other than the pay envelope. This serves to emphasize the fact that engineers must in the future strive to pay more attention to that part of their profession which deals with the direction of men as contrasted to the control of materials and processes.

OPERATING LABOR COSTS IN CHEMICAL PLANTS

nificance to all people involved in the management and engineering functions of a chemical plant. All are familiar with the rise in labor costs since the end of World War II, and in addition, wage rates in the chemical industry are among the highest paid in American industry. With the prospect of a continuing rise in labor costs, competitive success—yes, even survival, depends on effective utilization of labor and the best techniques in labor cost control.

For an understanding of the subject it will be necessary to describe the nature of the work that a typical chemical operator performs. First the industry's hourly paid workers, classified as production workers, can be divided into three groups:

(1) process workers who operate chemical processing equipment

(2) mechanical workers who install, maintain, alter, and repair plant machinery and equipment

(3) miscellaneous workers, such as material handlers, truck drivers, factory clerks.

This third group is generally referred to as indirect labor. Direct operating labor costs generally deal with the first group, the process workers, and treatment in the article here will emphasize controlling costs for this group. However, discussion of direct labor costs cannot be complete without occasional reference to the maintenance and indirect forces.

It is helpful to contrast the work of the chemical process operator with his counterpart in the mechanical or fabricating industry. In the fabricating industry the work is normally repetitive in nature and of relatively short cycles. The job content is easily determined, and measurement of labor requirement is relatively simple. The sum of physical activity plus machine attention time usually amounts to close to 60 min. of work/hr. In the chemical plant the work is different. Although some job elements are repetitive, there frequently exists no recognizable cycle. Since the work is varied and dependent upon current process conditions, the job content is not always easily determined, and measurement of labor requirements is not so exact as in repetitive operations. Physical activity is frequently an unimportant aspect of the work, and attention or stand-by time may occupy a large portion of the operator's day. As a matter of fact, when the process is operating efficiently, the operator sometimes has little to do. To provide something specific, two simple types of chemical processes are examined: the first one is representative of high manual labor content with little or no instrumentation or mechanization, and the second, while simple, involves little manual labor and is highly instrumented, continuous, and automatic.

Training Operators in Repetitive and Process-Type Industries

In many fabricating industries, an operator comes equipped with a basic knowledge and background, for example, the machinist, tinsmith, and welder. With this type of worker, it is necessary merely to orient him to the particular requirements of the plant, after which he is ready to produce. In hand manipulating types of work, the worker usually requires specific training on a special job. Examples are packing small finished products, such as tooth paste, operating small automatic machines as in the light metal and plastic molding plants, or just plain assembling accomplished at a bench or special work place.

In the chemical industry training is not so easily accomplished, if effective operation is desired. The work encompasses less routine and engenders mental skill and process know-how. An operator in one plant may find process conditions and know-how requirements vastly different when he moves to another plant. Unless an operator is trained and retrained at regular intervals, he misses many key points in his job to the economic detriment of the business.

Frequently one operator stands out in performance. Not only does he accomplish his physical work in a minimum time, but in addition, operates smoothly with fewer process emergencies. Also this same man usually gets better performance in such things as product yield, utilities consumption (steam, air, power), and quality. By observing the activities of the best operators, plant supervision can use their methods to retrain the other men to higher levels of performance. In any consideration of chemical plant costs, training must be taken into account as an integral part of good management.

Another distinction of the chemical industry is the normally low ratio of labor cost to all other costs. This can be a psychological deterrent to good management practice. In the fabricating industry labor costs average between 35 and 50% of operating costs and may go as high as 75% in selected products. In the chemical industry labor may be as little as 5% of the total operating cost. This condition has a tendency to cause many managers to feel that labor is so inconsiderable as to be unworthy of the pain of cost control.

Using labor ratios alone is a spurious measure of the need for cost reduction and control. In many older processes technological progress has proceeded to the point where continuing improvement is slow. This situation leaves labor economies as the best source of improvement and reduction of product cost. Those who are prone to neglect the low labor ratio items of cost are forgetting that:

1. Every excess individual on the rolls today represents costs of between $5,000 to $10,000, including associated overhead costs.
2. In this day of product competitiveness, even a few cents per pound reduced cost can contribute greatly to a product's longevity on the market.
3. Cost reduction and control constitute a mental pattern and practice which must be universally utilized. Slipshod methods in one cost realm can easily contribute to malignant complacency in another.
4. Good labor cost control usually contributes collateral benefits in better operation, lower manufacturing costs (other than labor), and better labor morale.

Now one can examine the factors controlling direct labor costs in a chemical operation. These are as follows:

1. process design, type of process, degree of mechanization
2. plant layout—work route and degree to which operation is centralized
3. physical location of manual controls
4. method of measuring job content and thus labor requirements
5. training of operators
6. adequacy of direct supervision and management
7. excellence, or lack of it, of cost control system
8. condition of labor morale—esprit de corps—part of team
9. job methods and procedures.

Supervision

As training has been shown to be an important facet in labor costs so does supervision play a vital role. Many managers feel that perfect supervision would eliminate the need for any control devices and would produce optimum manufacturing costs. The complexity of industry today makes it impossible for even an excellent supervisor to manage, supervise, and control every aspect of the business with which he is entrusted unless he is given proper support by the staff functions.

Supervision's role then is not masterminding every aspect of his domain, but rather integrating his direct functions with the policies and systematic procedures supplied by management through staff facilities. Where standard cost systems are used, the supervisor is the key man on their administration. No matter how excellent the plan, failure on the part of supervision to back the program or to take advantage of its quantitative and qualitative attributes will neutralize and negate the potential of this cost reduction device.

Method and Procedure

It must first be recognized, that methods and procedures, in the main, are built into the typical instrumented or automatically controlled process. The normal motion economy principles or work simplification rules are relatively ineffective in this type of operation. Methods improvements in an automatically controlled process are usually oriented to chemical engineering technology rather than to labor. There are, however, many processes in the chemical industry which are still not highly automatically controlled. In process No. 1, for example, considerable material is handled by labor—to the reactor, from the dryer to the elevator; from the screen to temporary storage; from temporary storage to the warehouse. Here there are numerous opportunities for labor-saving devices and procedures. A few tentative possibilities are:

1. raw material conveyor, lift trucks, special hopper unloaders
2. conveyors to elevator, drum lift trucks or rearrangement to unload dryer directly into the elevator
3. palletization or conveyorizing of finished product to permanent storage, eliminating need for temporary storage by a proper scheduling system.

Even in the semiautomatically controlled process there exists some potential for improved methods, since designers and construction people may have neglected the labor aspects of process design. For example, in a plant such as process No. 2, one or several of the following high-cost conditions might be found:

1. lack of centralization of process controls—operators required to run up and down stairs to start pumps, check instruments, take level readings, open valves, add ingredients
2. placement of controls beyond normal reach of operators, requiring standing on ladders, drums, etc., to operate.
3. neglect of automatic features, such as temperature controllers, pressure regulators, level indicators and controllers, pH instruments, and process interlocks desirable for both automatic control and safety.
4. Clean out operations—even in an automatic process occasionally certain tanks and vessels have to be washed out or cleaned out. Small consideration sometimes given to the methods of washing, cleaning, and disposing of the waste material.

Hence, prior to any control consideration it is necessary to investigate the existing methods for adequacy and to develop the best process methods before attempting to measure the need for labor. The best opportunity for methods exists before construction, that is, during the design stage of the process.

There are a number of ways of determining process labor requirements and maintaining the proper process crew sizes throughout the years, regardless of technological and other process changes. One way is to compare the process with similar ones and then staff it with a like number of people. A second method consists of permitting process supervisors to estimate the labor requirement based on their experience. The third method consists of actually measuring the labor requirements based on work content in the process.

The first two methods, while simple and often most palatable, do not permit an accurate determination. Even worse, as process conditions change, it is almost impossible to adjust the manpower needs properly. As the years pass, labor effectiveness frequently de-

creases to as little as 40% where measurement is lacking. It is not unusual to find twice as many people as necessary in a process that has not been subject to measurement. Since measurement is one of the direct tools of labor cost control, a little detail concerning the method may be warranted. After it has been determined that the best methods available are in effect, the job or process is analyzed for work content (Table 1). This is a typical job breakdown based on process No. 2. The work elements are determined from:

1. observation of work performed by operators
2. study of process or operational manuals.
3. review of process flow sheets
4. review of job requirements with process supervision

After the work elements are determined or are coincidental with their determination, appropriate time values are assigned to the various work elements. Here the normal agency for time determination is direct time study, although this does not preclude the use of standard data (predetermined elemental times) or work sampling which develops time values based on random sampling and statistical techniques.

The next step is determination of the frequency with which the various work elements occur. How often is it necessary to measure levels in the purifier storage tank? How frequently should still temperature be checked? How often should steam and water flows be checked and adjusted in various parts of the process? How frequently and how much filter medium should be added to the filter? Answers to these questions are obviously vital to proper assessment of working job content.

This information can be gleaned from observation (although this may often lead to erroneous conclusions), discussions with direct process supervision, or the study of standard operating procedures. Incidentally, here the study people can contribute greatly by suggesting, as a result of their analysis, the elimination of unnecesary work or simplification through reduced frequency of needed work. In one case a group of operators was shutting a process tank down for cleaning out sludge every two days. The work involved several process hours, high-labor cost, and loss of precious process capacity. The study engineer in his observation noted on two occasions that the actual amount of sludge appeared to be, in his opinion, small. He suggested reducing the clean-out frequency by a factor of two. On the basis of this stimulus, it was decided to try

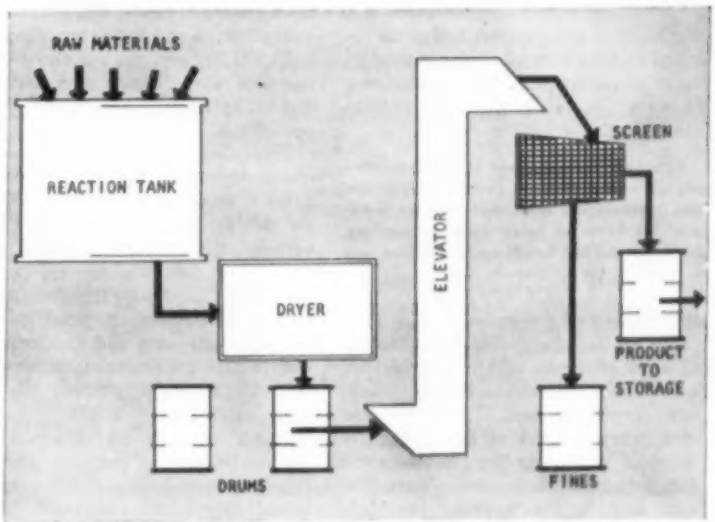


Fig. 1. In process No. 1 the operator dumps raw materials into the reactor by hand, removes semifinished products in drums, moves the drums to the elevator boot, and finally moves the product drums to storage. The considerable manual effort in this sequence of operations occupies a large part of the working period.

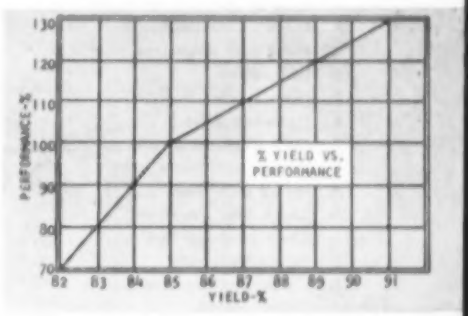
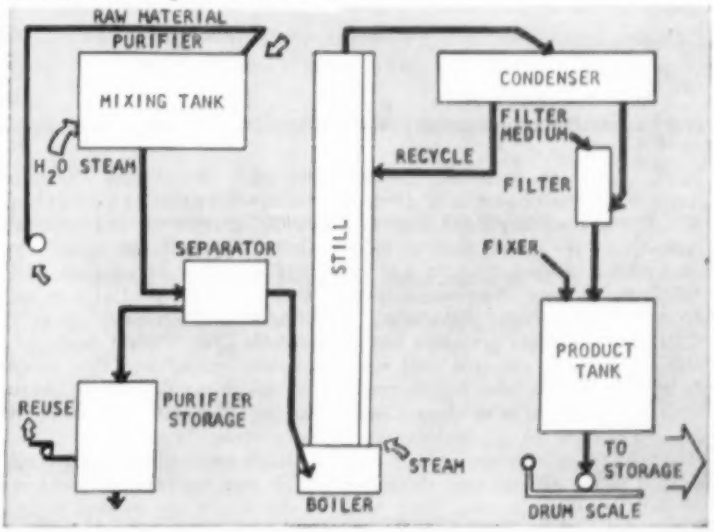


Fig. 3. Method of determining effectiveness on the yield factor (process No. 2).

Fig. 2. In process No. 2 there is no real manual effort except at the end where the drum is rolled onto the conveyor and even this is minimal. The majority of the work involves pushing switches, operating valves, reading instruments, and general attention time. Many of the modern chemical processes are almost completely automatic; they utilize controlling instruments with safeguards and interlocks.



the idea out. It worked, and within a few months the cleanout had been reduced to once a week with no impairment of quality and with a gratifying reduction in labor cost and process down-time.

Remember, people closest to a process often are prone to neglect the obvious. It is a common psychological quirk that after an individual has looked at something for a long time, he begins to feel that there is only one way in which it can be properly done.

Man-Hours and Processing

Up to this point the determination of work elements, assignment of time values, and the necessary frequencies have been discussed. To arrive now at a representation of the man-hours required to operate the process, some rational unit must be chosen first. The unit may be the working period, a batch, yards of material, machine hours, or thousand pounds of production. In the chemical process, it is most desirable to use a unit, such as thousand pounds of production, so that the calculation of labor effectiveness is independent of operator reporting.

Production figures are easily attainable and accurate and will yield more reliable figures on labor effectiveness. This is a complete work sheet (Table 2) for process No. 2, showing work elements, times, frequencies, and conversion to the rational unit, thousands of pounds. The clean-out filter tank is an example. Since this occurs once in eight days and the process capacity is 10,000 lb./day, the minutes per occurrence for cleaning the tank are divided by 80 to get minutes/1,000 lb. production.

Totalizing the elemental values, one comes up with the total minutes/1,000 lb. production required to operate this process. In this example conversion from minutes/1,000 lb. to men shows that two men are required for 10,000 lb./day. Variations in production will reflect the need for more or less manpower and the standards will require no alteration unless a significant change in method has been made.

Labor effectiveness is usually expressed in terms of per cent. Thus, the standard man-hours divided by the actual man-hours used will be the per cent effectiveness. Management can use this figure as a control in manpower assignment and cost control. Quite frequently, an area, say with four operators, is assigned additional work in an adjacent area in order to bring the effectiveness up to an acceptable level. Table 3 shows the effectiveness values for this process at various production levels. At 13,000-lb. level the crew size would require adjustment.

With process No. 2, a typical standard cost application is observed in Table 4. In this process there are a number of key cost items which, if poorly managed, can represent important cost penalties.

1. *Labor cost.* This is couched in terms of dollars per 1,000 pounds of product produced.
2. *Raw material consumption.* This can be minimized by careful adherence to operating instructions. Materials must be carefully weighed and waste must be reduced to a minimum. This again is being measured in terms of pounds of raw material per 1,000 pounds of product produced.
3. *Yield.* This is calculated stoichiometrically on the basis of chemical reactions and anticipated losses in the various parts of the process. This is measured in terms of percentages.
4. *Steam consumption.* A great deal of steam is used in the reaction tank and in the still boiler. Careful operation in following heating schedules and watching temperatures will reduce steam consumption to the minimum. Also conscientious watch over steam leaks, relief valves, etc., will reduce waste of steam. Calculation of the standard here is thermodynamic and involves knowledge of heat transfer and still operation. The unit chosen is pound steam per 1,000 pounds of product produced.
5. *Quality.* Quality is measured in terms of purity of the end product. This may be expressed either as a percentage or a concrete number representing the level of quality desired. The standard is based on process characteristics and market demand.

In the example shown it will be noticed that each cost item is shown in terms of standard cost for the period, actual cost, and variance. In each case variances exceeding 10%, say, require an explanation as to cause with a proposal for reducing the variance in the coming period. Obviously, the emphasis placed on control along with the handy measure provides management with a potent tool for reducing costs. The labor cost is an example. The large variance in this case was caused by additional work occasioned by product reworking. The reworking resulted from poor operation in the mixing unit and was the direct responsibility of the process supervisor. There is little question as to what his plans will be for the coming cost period.

Wage Incentives

There remains one important operating area of cost control, namely the area of wage incentives. Prior to establishment of any incentive system, it is necessary to eliminate most operation difficulties. It is further desirable that all work be well standardized and

Table 1.—Job Breakdown to Operate Still.

	Element description	Freq./unit/shift						Min. shift
		1	4	8	12	16	24	
1.	Walk to still						.75	18.00
2.	Check column temp.						1.30	7.20
3.	Check auto steam cont.			1.20				9.60
4.	Take sample			1.50				12.00
5.	Check purity				.60			7.20
6.	Open vent valve		.80					3.20
7.	Sight check reflux ratio						.20	4.80
8.	Open bypass steam valve		1.00					4.00
9.	Record plate temp.			2.50				20.00
10.	Check filter rotameter		.50					2.00
11.	Check condenser H_2O		.30					1.20
12.	Review instr. panel					1.60		25.60
13.	Check separator level				.40			4.80
14.	Sample recycle			1.40				11.20
15.	Samples to control lab.			2.50				20.00
16.	Record sample results			1.70				13.60
17.	Clean gauge glasses	15.00						15.00
18.	Attention time						1.00	24.00
19.	Shift records	10.00						10.00
20.	Instructions		2.00					8.00
21.	Clean up area	15.00						15.00
						Total time—minutes		241.40
						10% allowance		24.10
								265.50

that the methods and procedures are the best that can be achieved under the existing conditions.

Before incentives are put into effect, it is imperative that all standards be tested for accuracy, consistency, and attainability. The time to correct errors is before, not after, the incentive system has been put into effect. Assuming that all preliminaries have been cared for, what is the proper incentive plan for chemical operations? Theoretically, many are available, but only a few have been found adaptable to a chemical plant. The Bedeaux system and the Standard Hour plans have been employed. For discussion here the standard hour plan has been chosen for it is simple to understand and administer.

Labor standards are set in terms of standard hours per task which are then compared with actual hours consumed. For example, a job with a standard of 8 hr. takes 10 hr. to perform. The effectiveness is 80%. In order to earn incentive or extra pay, this effectiveness figure must exceed 100%. Then the operator is paid a portion or all the savings he effects, depending on plant policy.

In process No. 2, if the standard man-hours for a 24-hr. period are 60 and if the work accomplished is 48, the effectiveness is 125%. The operator's earnings then would be 1.25 base rate, if the incentive system applies to labor alone. In the chemical industry, however, incentives can be applied to other cost factors than labor. In fact, the potential gain from other than labor factors is much greater than from labor alone.

Multiple Factor Incentives

The value of incentives for other than labor cost factors should be emphasized. One case is vividly recalled, in which installation of a steam-conservation factor saved many thousands of dollars a year by merely motivating the operator to adhere closely to a steam use schedule. The application involved a vacuum-type evaporator or crystallizer. Methods studies disclosed that the operators were using "booster" steam throughout the evaporative cycle. This involved a 4-in. steam valve. The operating schedule called for the use of a 1-in. valve until the vacuum had reached 20 in. Hg. Use of the valve throughout the cycle was wasting steam, but the divergence from normal operation was hard to control by normal supervisory methods. When steam consumption was placed on incentives and the proper operation explained to all the operators, the steam usage plummeted downward. Why not—now each operator had a personal monetary stake in saving steam! This is typical of a hundred similar improvements in quality, utilities consumption, and materials usage through the use of multiple-factor incentives. Table 5 shows a complete multiple factor incentive set-up. Included are the standards, a typical performance, the method of calculating over-all effectiveness and the premium calculation. (See Figure 3, page 467).

Preventives

Prestart-up cost control can be accomplished at the best time to improve a process—before it is built. Proper design and construction of a new or improved process is a cooperative effort involving research, design, engineering, and construction men. Re-

Table 2.—Process No. 2—Recapitulation Sheet.

	Min./shift	Min./occ.	Freq./day	Freq./1,000 lb.	Min./1,000 lb.
1. Prepare raw materials	42.0		3	.3	126.0
2. Operate mixing tank	125.0		3	.3	37.5
3. Attention storage tank and separator	32.0		3	.3	9.6
4. Operate still	266.0		3	.3	79.8
5. Attention to filter	187.0		3	.3	56.1
6. Clean out storage tank		300.0	1/20	.005	1.5
7. Clean out filter tank		500.0	1/8	.0125	6.25
8. Attention to product tank	67.0		3	.3	20.1
9. Area housekeeping	15.0		3	.3	4.5
Total min./1,000 lb.					228.0

Process capacity—10,000 lb./day
Total operating standard 228.0 min./1,000 lb. produced
Can be converted to labor cost/1,000 lb. or 1,000 lb./labor dollar

$$\frac{228 \times 10{,}000}{1{,}000 \times 3 \times 480} = 1.6 \text{ men}$$

Table 3.—Process No. 2—Effectiveness Calculation.

(Assume 10,000 lb production)

$$\text{Effectiveness} = \frac{\text{Std. hr.}}{\text{Actual hr.}}$$

$$= \frac{228 \times 10{,}000}{1{,}000 \times 60 \times 2 \times 24} = 79\%$$

Table of effectiveness values for various production levels using a two-man crew.

Production (Daily cutoff)	Standard hours	Actual hours	% Effectiveness
5,000	19.0	48.0	40
6,000	22.8	48.0	48
7,000	26.6	48.0	56
8,000	30.4	48.0	64
9,000	34.2	48.0	71
10,000	38.0	48.0	79
11,000	41.8	48.0	87
→12,000	45.5	48.0	95
13,000	49.5	48.0	103
14,000	53.2	48.0	111
15,000	57.0	48.0	119

→Break point without incentive.

Table 4.—Process No. 2—Standard Cost Plan.

Cost factor	Unit of measure	Standard	Actual	Variance
1. Labor $2.50/hr.	$/1,000 lb. prod.	$9.50	$11.70	—$2.20
2. Raw materials	$/1,000 lb. prod.	1,560 lb.	1,800 lb.	—240 lb.
3. Yield	%	85	86.5	+1.5%
4. Steam	$/1,000 lb. prod.	25	22	+3.0 lb.
5. Quality (purity)	% purity	97.5	97.0	—0.5%

Table 5.—Process No. 2—Multiple Factor Incentive Plan.

Factor	Factor weight	Standard	Actual	Per cent	
1. Labor	30	100%	120%	120	36.0
2. Raw material	20	1,560 lb.	1,430 lb.	110	22.0
3. Yield	20	85%	88%	115	23.0
4. Steam	20	25 lb.	25 lb.	100	20.0
5. Quality	10	97.5%	97.0%	120	12.0
Weighted average					113.0%

Earnings calculation: Base rate × incentive rate = earnings 2.50 × 1.13 = $2.83/hr.

search people have as their objective the formulation of a productive process.

Design engineers think primarily of functional layout and equipment specification. It remains for some engineering study group to consider in advance the design considerations affecting proper utilization of labor. In the DuPont company industrial engineers work cooperatively with research, design, and construction in these fields:

1. *Basic data development* in the fields of office requirements, service needs such as medical, guard forces, cafeteria, building sizes, equipment layout, and advanced estimates of labor requirements.
2. *Operation analyses* depicting in advance the nature of the labor operations that will be required and suggesting specific centralization of operating controls and location for ease of operation. This sort of planning often can mean the saving of an operator per shift in a single chemical process.
3. *Start-up programs* involving prestart-up training of operators, written operating instructions, emergency operating plans, production schedules, planned maintenance and follow-up during the initial phases of actual production.

In this program of prestart-up analysis, it is necessary for an engineer familiar with industrial engineering principles to work regularly with research, design, and construction personnel even to the point of reviewing layout and equipment drawings. Only in this way can one be certain that the utmost in labor economies has been designed and built into the new process. The plant then designed for economy, staffed for economy, and started up on a planned efficient basis, is off to a good start, the advantages of which usually make themselves felt for years. After the process has been operated for a while and has become stabilized the normal industrial engineering practices, described previously, take over.

Motivations

Human relations play a strong part in the control of all operating costs including labor. Psychologists describe the most important motivations for good performance in the human being as follows:

1. **Financial gain**
2. **Search for security**
3. **Need for participation**
4. **Sense of belonging**

Good industrial management does its best to fulfill these human needs. Substantial wages commensurate with the industry in general and with the area in particular, usually fill the need for financial gain and partially the need for security. In addition, a properly administered incentive plan can supply additional financial gain as well as increased production and reduced costs.

The search for security can be satisfied by utilizing good benefit plans which include sick pay, vacations, insurance, hospitalization, shared savings, and retirement. In addition, a properly managed business recognizes the value of long service and by its recognition builds a greater sense of security with the passing years of service.

The need for participation and sense of belonging can best be fulfilled by competent, direct supervision and cleverly designed participation policies. Good supervision can build esprit de corps without which the best laid plans of management go awry. A properly run suggestion system provides a channel for participation through utilization of the thinking of hundreds of people. Occasionally a really significant suggestion contributes materially to direct cost reduction.

Still another device for bringing the operator into the act consists of acquainting him with some of management's problems. Considerable success has been obtained by training operators in the supervisory problems of their process as well as in the cost aspects of both material and labor. Man's natural response to being part of the team often makes him sympathetic to the supervisors' problems and anxious to help in their solution. In reverse, a supervisor who keeps his distance and refuses haughtily to discuss his problems with his men will get no cooperation whatsoever.

A properly managed enterprise will always maintain control of its labor costs. On the assumption that some measure of labor requirements is available, it becomes important to maintain this measurement, that is, keep it up to date. Any process change, affecting the use of labor, should be promptly followed by adjustment in the labor force. Psychologically, labor adjustments cannot be adequately explained six months after the process change that occasioned such adjustments.

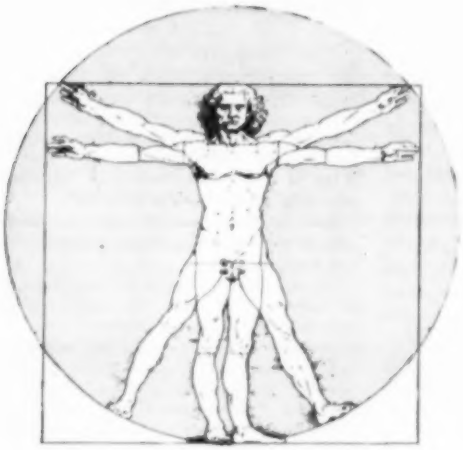
A good example of this sort of thing is a process that had four operators a shift for over three years. Market conditions caused the company to discontinue one phase of the process representing about 40 per cent of the total labor required. While supervision certainly recognized the need for less labor, it procrastinated and temporarily made work for the entire crew of four, hoping it could quickly find enough additional useful work to use the full crew effectively. After a year had passed it was decided to combine the work of three processes into two, thus fully utilizing the aforementioned crew of four once more. Unfortunately, the passage of time had made the operators forget that they had once handled 40 per cent more process. The resistance to consolidation was so great that the move was deferred indefinitely.

Engineers and managers have always faced a formidable challenge in the control of manufacturing costs. The challenge today is greater than ever, and in the next decade it will become powerful enough to defeat any management not intelligent enough and courageous enough to face the issue squarely. Labor costs are steadily rising, unions are demanding more, not only in direct wages, but in fringe benefits, such as overtime pay, extra holidays, and call-in allowances. Already initial agitation for the four-day week without decreased pay is common talk and there is constant pressure tending to raise the labor dollar percentage with respect to total product cost.

It is true that the trend toward automatic control in the chemical industry will partially counteract rising labor costs, but this same automatic control intensifies the problem for indirect labor, particularly in maintenance and similar nondirect costs. Already one feels pressure for higher job ratings and basic wages because of this automatic control. Some claims have been made that the skill needed to operate an automatic plant is so high as to place the job in the same category with wage roll jobs requiring the highest mental skills.

In 1940 batch processes were relatively heavy in labor, but the labor part of the production dollar was low. In 1957 continuous processes, with a high degree of instrumentation, mean lower man-hours, but labor dollars are about the same. In 1970 what can we foresee—electronically controlled, almost completely automatic processes with radiation catalyzation and instantaneous reactions; high-speed processes with materials flowing through in a fraction of present-day rates. With all of this we will still have labor. A different type, more expensive labor to tend to process computers and balance the delicate interplay of forces, but still labor which will require some type of measure and a great deal of control.

Presented at A.I.Ch.E. meeting, Baltimore, Maryland.



HUMAN ENGINEERING

and . . . direct operating labor costs in chemical plants

Bruce L. Cusack * | Ground Systems Division, Hughes Aircraft Company
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The application of "human engineering" to the problem of the man-machine system of today answers such questions as: "Is man superior to the machine?" or "Will the machine completely replace man?"

What is "human engineering"? This term probably requires an explanation since many doubtlessly have never heard of the relatively new field it covers, or have only a hazy notion of what it attempts to do. The formal definition specifies that human engineering is concerned with increasing a man-machine-system effectiveness by a study of the interrelationships between these components as a unified system whole, rather than as separate entities (*17*). Probably a more meaningful definition, however, is simply a reversal of the traditional psychological concern of "fitting the man to the job" and saying that human engineering tries to "fit the job to the man."

The title *human engineer* has proven to be an unfortunate choice since such a name has a definite, negative connotation to both engineers and laymen. For the engineer such a name seems to imply that other engineers are inhuman or subhuman, while for the laymen the name seems to mean some sort of cold-blooded manipulation of people. One might even picture the result of human engineering as a telephone operator with great big ears and one perfectly engineered digit for dialing purposes. To try to overcome this reaction, a series of other terms has been proposed for this discipline, such as engineering psychology, human-factors research, biotechnology, applied experimental psychology, and so on, but none have caught on. It appears that the term *human engineering* has rung the bell and is here to stay.

Purpose and Function

The functions of human engineering are frequently confused with those of industrial and design engineering. Making a distinction between them is important for several reasons: (*1*) to prevent industrial and design engineers from feeling that human engineers are trying to take over their fields, (*2*) to promote harmony between these and other types of engineers since human engineers are frequently incorporated into a team, and (*3*) to promote understanding of what human engineering does so that it is properly applied within the various organizations, and thus its benefits realizable. The last-named obviously cannot happen if the human engineer is forced into activities which might better be left to the design or industrial engineer.

The first distinction between these fields of endeavor is the fairly obvious one of emphasis—the human engineer is most concerned with the man in a system, the industrial engineer is primarily interested in the system from the management point of view; the design engineer is much more attentive to the machine part of the system. This emphasis really reflects training, of course, with the human engineer usually trained as an experimental psychologist and therefore rather deficient in engineering skills whereas the other two are less concerned with knowledge of an operator's capabilities and limitations. Another distinction is in the methods used to arrive at answers, with the industrial and design engineer using a more traditional methodology upon which each can rely, while the human engineer heavily stresses experimental investigations. This can be at least partially attributed to the fact that as yet no comprehensive theory of human engineering has been developed. As a result, each problem confronting the human engineer has to be solved almost without precedent and as a unique experience.

It is obvious that no one of these engineering disciplines has the requisite knowledge to arrive at the best answer alone, hence the team concept in design and industry has come into being and has proven to be a powerful tool which recalls the old adage that "many heads are better than one." Further, it would appear that the team concept will become more and more evident as time goes on with an increase in specialization and complexity.

The Human Engineer's Tools

The primary tools of the human engineer are man's sensory modalities, with special emphasis on vision and audition. In an examination of the sensory capabilities of man, one starts off with vision. The eye is capable of seeing a range of light energy in the order of one hundred million units,

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ranging upward from a few quanta (*17*). This fact of sensitivity can be readily grasped by stating that the energy realized from dropping an average-sized pea a distance of 1 in., if converted into light, would enable the entire population of the earth to see a little flash of light (*16*). In terms of minimum perceptibility (the smallest thing one can see), the eye is equally amazing with the minimum being about one-half second of visual angle, or roughly the equivalent of seeing a ⅛-in. wire at a half-mile's distance (*17*).

In fact, the eye is such an amazingly well-engineered device that increasing visual acuity only about 1% would really decrease its effectiveness since everybody would be bothered by seeing his own blood corpuscles swimming past the visual field. Indeed, under certain conditions one can do just that, such as when an indeterminate focus (focus myopia) occurs. Twilight is a period of day which represents a sort of indeterminate focus with color and form distinction lacking, and for this reason it has been suggested as an explanation of why so many flying-saucer reports are timed at sundown—the observers are seeing their own blood corpuscles.

Another sense modality under consideration here is audition. The range of sound intensities that a man can feel is of the order of ten trillion units from the least to the point of pain (*17*). Auditory perception is so good, in fact, that there is reason to believe that supersensitive people can hear random Brownian movement (*11*). The auditory system is also so well engineered that a little increase in its perceptibility, about 1%, would also play "hob" since most people would then hear the blood rushing through the veins of their ears.

Limitations or Constants?

As wonderful as these sense modalities are, one must realize that there are limits to them beyond which one must not design equipment. The "pass band" characteristics of the human are about twenty to 20,000 c. for audition and from about four to 7,000 Å units for vision. Reaction time averages about 250 millisec., although it can be reduced to about 150 by proper use of anticipation.

Concerning his muscle force, man can exert about 200 lb. for a short time in lifting, and about 50 lb. with his arms alone. For force control, however, the range of accuracy and efficiency extends from about 1 to 10 lb., above and below which precision falls off rapidly (*1*). It is for this reason that pilots had so much difficulty flying jets when their controls were initially designed free of inertia, and explains why a person loses the "feel of the road" in cars with total power steering. Man's input channels are easily saturated with a limit of about eight to ten successive items per second, but attention must be paid to avoid competing, overlapping, or incompatible inputs. These characteristics of the human "pass band" may be thought of as limitations, but the human engineer much prefers to consider them as design constants to which the machines must correspond in order to arrive at the best system performance. After all, technological skills have been increasing by leaps and bounds, such increase resulting in more and more complex equipment, but man remains unchanged.

What Human Engineering Has Discovered

What then is the application of this information to chemical engineering? This question can be answered by citing a few examples of what human engineering has accomplished. A good part of the classic work of human engineering, if anything that is only about ten years old can be called classic, has to do with displays and controls which confront the human operator. The role of displays and controls in initiating human engineering is fairly obvious since they so directly influence and are influenced by the human in the system. Also, it might be remarked that in the initial stages of human-engineering effort its proponents were not too sophisticated, and experimenting and designing knobs, and tracking sticks and dials, offered an easy and obvious way of getting started. It must be added, however, that the field has progressed a long way, with the display, control, and panel design usually a result of a systems analysis rather than of the more piecemeal improvement of components.

One of the most productive early researches in human engineering investigated the reasons for pilot-caused accidents in the air force (*4*). Some 270 accidents and near-accidents were surveyed and it was found that a good number, pilot accidents, that is, consisted of misreading a dial, with most of the errors related in some fashion to inadequacy of the dial design. For example, forty of the errors were gross misreading as eleven o'clock for twelve o'clock; twenty-four involved confusing two dials that looked alike; fifteen involved reading a wrong number from the scale; and five were due to failure to notice a warning light; or a reliability indicator did not inform whether an instrument was on or off.

This study offered a steppingstone for experimental work on dials, and some important results can be noted:

Increasing the number of markings on a dial face does not increase the precision with which it can be read; it does increase the likelihood of a gross error while it is being read.

Scale readings should increase in a clockwise direction and should have constant spacing throughout.

The dial doesn't have to be complicated to be confusing, and it does not require tremendous expense to help the operator.

A simple thing like indicating the normal range of dial is of great help (see Figure 1a, 1b and 1c), and in a bank of dials it is of further help to locate the normal range in the same position, preferably straight up (5).

Obviously even such uncomplicated rules as these have application to chemical engineering where so much time and reliance are placed upon the operator's ability to read and interpret such dials.

The character of such statements concerning dials is probably looked upon by many people as being just common sense. From this reaction they conclude that human engineering is simply the application of common sense to design. In a sense they are right, of course, since it really is just common sense to locate displays where they can be seen and controls where they can be reached, and arriving at a conclusion such as this takes no special sort of training. Unfortunately, however, common sense is not the sort of design criterion that can be trusted since it varies as a function of the times and the culture.

Common sense dictated the design of the artificial horizon in airplanes, with that instrument showing a miniature airplane in the center of a dial which remains stationary while a line which represents the horizon rotates left or right as the airplane banks. A good case can be made for this sort of display since this representation is exactly what the pilot sees out of his windshield. When you bank an airplane to the left, it does appear as if the horizon tilts to the right. However, human-engineering research has conclusively shown that a display which reverses this procedure and fixes the horizon while tilting the airplane in the display is much superior. Apparently it is easier for pilots to relate what is going on from a ground-fixed representation rather than from an aircraft-referenced one (2).

Another example of how common sense can lead one astray:

An apparently incompatible problem concerned boiler factory noise and the requirement of verbal communication between the workers. It seemed sensible that putting earplugs in the workers' ears would succeed in decreasing the intensity of sound, but what effect would you think it would have on speech

intelligibility? Contrary to common sense, it greatly increased it (2).

Other case histories can be listed but here it is pertinent to summarize the findings of human engineering into two general categories: (1) where man is superior to machines, and (2) where machines are superior to man. Man is superior for decisions, adaptability, long-term memory, and reasoning, while machines excel for accuracy and reliability, and speed of computation, routine, power, short-term memory (*15*). In one other respect man is superior to the machine. However, it is a nondescript characteristic which doesn't fit neatly under a one-word title and, furthermore, its practical usefulness is doubtful. Specifically, at New York University it was found that man can extract intelligence from a signal which is about 20 db. below a random noise level, which no machine even approaches. And man can't be sold short as a computer either, since in hovering a helicopter over a fixed point, it has been computed that the pilot is providing the solution for some twelve simultaneous equations (*11*). It even takes a rather fancy integration for a little boy to knock the hat off a passing man with a snowball.

Automation, Direction Operating Costs, and Human-Engineering Implications

It has been stated frequently that automation will have an impact on society that will be second only to that of the first industrial revolution. The purpose in discussing it from the standpoint of human engineering is certainly not a reactionary view of "let's keep the man in the system"; rather, is it to show what contributions human engineering will be able to make to the coming automatic situation, and the transient one of semi-automatic which applies to many industrial situations today.

There has been much dodging and evasiveness on what automation's greatest benefit to industry will be and why industry will incur the expense of going automationwise. It is specifically the replacement of direct operating labor. After all, machines are faster, more reliable, more consistent, more powerful; they never get tired, talk back, go out on strike, ask for higher wages or fringe benefits (*8*).

Automation, however, is certainly not going to replace all people in the process, but rather shift the emphasis of their use and training. Maintenance, trouble-shooting, programming, decision making, and monitoring are some of the human activities that are sure to be increased in the automated plant.

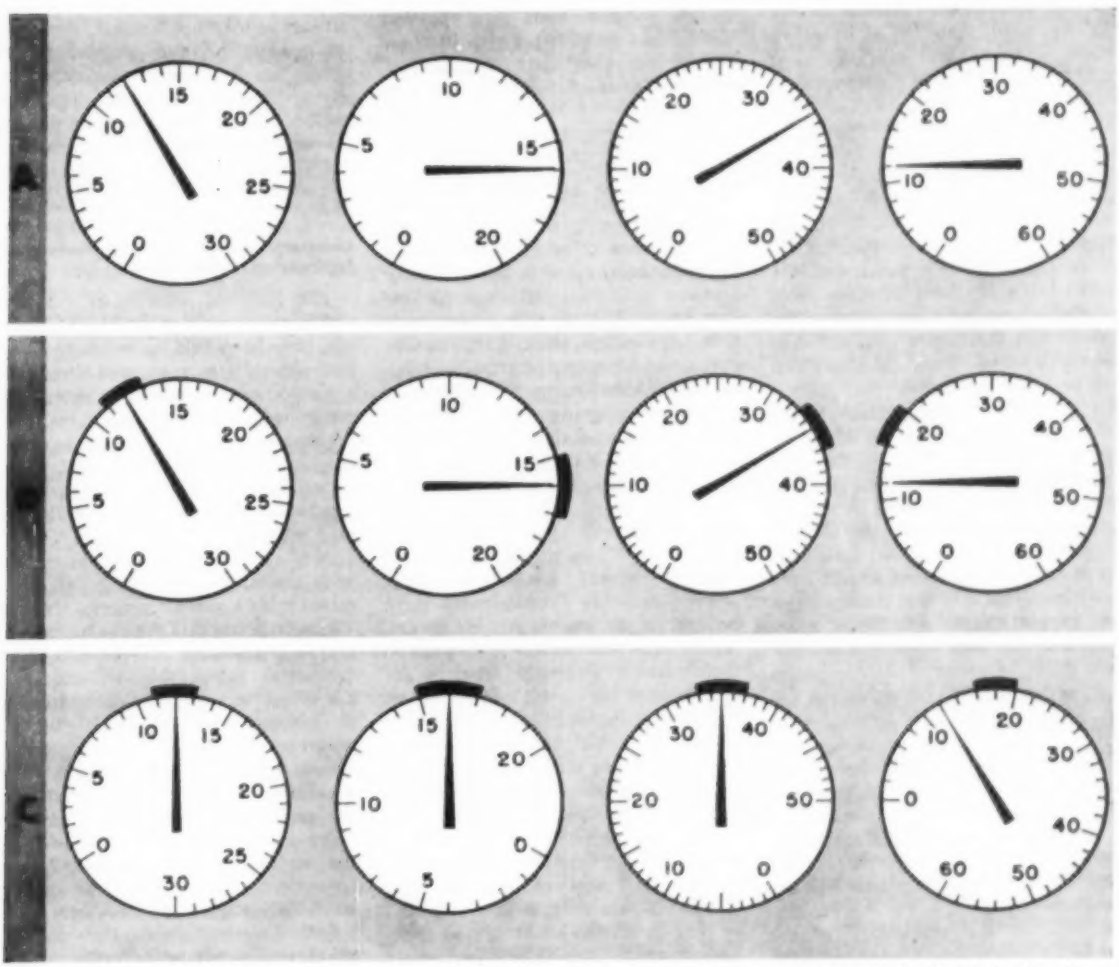

Fig. 1. A simple but effective human engineering design showing increasing ease of interpretation of a bank of dials (after 6.)

MONITORING

Take the case of monitoring. Even in the most fully automatic situation possible human monitors will be provided if for no other reason than that the equipment represents a large in-

vestment, and even monitoring equipment has been known to malfunction, but the human monitor just keeps plugging away. Centralized control will probably be the result of this sort of compromise between automation and human monitoring, and this obviously means more displays and more controls for fewer operators remaining in the system. In effect, in such a situation, not only are the functions of a number of operators being pooled, but also the responsibilities that had been previously spread around. Therefore, it doesn't seem like a drastic step to state that these operators should be provided with the best possible design and arrangement of controls and displays for optimum efficiency. Now the question may be asked: "how good a monitor is man?" The answer, of course, is he is terrible, especially if he is asked to monitor without any special thought being devoted to the problems that will confront him. One is amazed that a human being has been so often relied upon as a monitor when his performance in that capacity is so poor. And there will be additional problems that will be posed by automation: the requirement for great attention to his job, but with little to do, and this situation leading to boredom; the fact that automation will remove the chance to practice the very skills that he will require during emergency; the need of a considerable training and little feeling of reward or accomplishment from the job. What can the human engineer suggest?

First of all, just keeping a monitor around in the event of an emergency and requiring the hourly reading log entry of displays is both economically foolish and psychologically naive. Participation and personal involvement in the activity going on provide for a much greater responsiveness to emergencies, greater feeling of accomplishment, and, even relief from some of the equipment pressure of automation (*9*). Here one is moving into the field of the psychology of the worker, which will be considered later. However, it certainly would appear desirable to all concerned if the design incorporated a work situation for the monitor that would not only provide him with better performance but also offer better monitoring and fewer equipment requirements.

Another important consideration concerns practicing the monitors in emergency procedure. Applications of this principle have been extremely successful, such as in preparing pilots for emergency conditions in link trainers and in training bombardiers to parallel manually their automatic equipment as if they were conducting the bomb run. A smooth, swift, and efficient transition to manual control can thus be achieved. Even fire drills in schools illustrate the point that practice in emergency procedure pays off.

Practicing emergency procedures can be made even more beneficial if the emergency can be simulated into the actual operating situation without warning and without knowledge that it is just a practice run. This sort of procedure also serves to subvert the boredom inherent in the monitoring situation. An example of application of this dual purpose practice is available in the radar early warning stations, where simulated targets can be introduced on the displays of the operators "to keep them on their toes."

Human Engineer and Trouble Shooting

What sort of assistance can the human engineer offer to a solution of the maintenance and trouble-shooting problems that arise from automation? One study of an automatic power station, for example, showed that routine preventive-maintenance practices tended to be almost completely ignored, a practice occasioning much more frequent shutdowns than had been expected (*10*). This in spite of any number of management notices posted on the bulletin board, as "you *will* perform your maintenance duties." Apparently some sort of habit conditioning of the workers ensues from an automatic plant where they become much more negligent, or perhaps indifferent. Again automation offers a dilemma in that training and skill required for maintenance and trouble-shooting on complex equipment is sure to require unusual personnel, perhaps even engineers, while on the other hand engineers are not going to be interested in this type of work. Assistance from the human engineer can be offered in terms of the design of equipment from the point of view of maintainability and trouble-shooting ease. Such aids as built-in trouble-shooting and fault-finding panels should be incorporated into the design, not as an afte-thought but as an integrated systems design effort, as well as such considerations as legibility of chassis and component markings, layout of space and components, illumination, color-coding and even the writing of maintenance handbooks which to date have won no prizes for understandability.

In any event, the ultimate success or failure of automation is going to be reliability and maintainability, and the design team, including the human engineer, is going to have to face up to this problem.

PROGRAMMING

Programming is going to become the queen of automation, and the influence of this man-machine system will exceed anything ever seen before, and, thus, this man-machine combination should certainly have all possible benefits of design applied to it. Once again the reduction of personnel together with increased responsibility must be called to attention as a plea for the most suitable design, not only for the well-recognized speed and reliability of the input-output equipment itself but for the human who must work with the machine. A good number of developments in computers are specifically designed to prevent or detect human errors at the input and in the instructions and too much cannot be said concerning the importance of this sort of effort.

Chemical Plants Today and Human Engineering Implications

The chemical industry as a whole, and particularly the petroleum industry, have been held up as paragons of automation. However, even here there are no completely automatic processing plants today, with the great majority of chemical plants falling somewhere between fully automatic and completely manual (*8*), and of course, the number of direct operating personnel also falls into the category of "in between," between the few associated with automation and the many associated with a manual process. It goes without stating that the obviousness of human-engineering application increases as the number of humans in the system increase. As pointed out in the previous part of this article the importance of human-engineering application is probably inverse to this obviousness, with the fewer people the greater the responsibilities and the more urgent the need for human engineering. On the other hand, special attention to displays and controls must be provided when the operators have such a direct influence upon the process, just as is indicated in that old saw that "to err is human."

Even with the semiautomatic equipment of today, and especially with the fully automatic equipment of tomorrow, the type of personnel that will be needed will not only be scarce but will also be operating under some of the conflicts that have been previously pointed out—lack of challenge and feeling of reward. Therefore, it behooves chemical companies to pay attention to feelings of satisfaction from the job. Surprisingly, although many studies consistently show it to be true, management often refuses to recognize

that salary *per se* is not the most important ingredient of job satisfaction (*6*). Consistently the important items concern a sense of accomplishment and the feeling that management appreciates this accomplishment.

ILLUMINATION AND PRODUCTION

No more graphic example of the effect of management interest upon operating labor is available than the famous Hawthorne studies (*14*), so named because they were carried out at the Hawthorne plant of Western Electric.

Initially, the studies were begun to learn the effect of illumination on production. As the level of illumination increased, so did production. However, after a certain level had been reached, light bulbs were changed in view of the workers without changing the level of light, and production still increased. Later on, work breaks were introduced, first in the morning and then in both morning and afternoon. Production increased as might be expected. However, the work breaks were then cancelled and production increased again.

From the results of these data and the verbalizations of the workers concerned in this study, one of the most important conclusions involving industrial motivation was drawn: namely, management interest in the workers, as expressed by experimental attention in this situation, motivated them to a point where other experimental variables were entirely subjugated.

FATIGUE AND PRODUCTION

Another study (*13*) pointed up the same conclusions, although this time the primary variable being investigated was worker fatigue. It was felt that a drug would enhance production by overcoming the feelings of fatigue; thus a group of workers was chosen whose records of production had been secretly kept. They were given the drug, and production rose about 14%. However, a control group of workers who were given a sugar pill also showed substantially increased production.

The social hierarchy within an industrial setting is going to exist whether or not management recognizes it. A social force can have some serious effects. Studies have shown (*9*), for example, that social pressure within a plant working with a piece-work salary motivation tends to depress the potential production of the efficient worker, apparently so as not to show up the slower producer. Thus, such coercion can be shown to be a stronger motivating force than money, and this sense of belongingness to the group can be useful to industry. In one rubber plant (*3*), for example, the process was so unique that no ideas concerning the speed with which to run the assembly belt in one stage of the operation were available. It was decided to make this a sort of test case, so one of the belts was controlled by an engineer, while a second was controlled by the workers themselves. Doubtless it is not surprising to find that not only did the workers run their belt faster, but they felt a lot better about the arrangement. Such a worker integrity is commonplace, but offering the opportunity for its appearance is all too often overlooked.

WORKER IN THE KNOW

Another tremendously important and interesting facet of worker efficiency is the knowledge of the results of his performance. The worker must be informed of the results of his efforts and promptly too for much evidence exists to show that any sort of delay in finding out these results has a derogatory effect. An area of application in human engineering based upon these results is called "quickening" (*1*), where it has been shown that delay of knowledge of results on the order of seconds is harmful.

Quickening is simply the speeding up of the results of an operator's actions in a feedback loop for a control process which is longer than a couple of seconds. It is implemented by plucking off the components of an integration process before the output stage, by amplifying them, by adding them algebraically, and then by feeding the result back to the operator. This sounds rather complicated, but the display is rather commonplace, usually taking the form of a two-pointer dial, with one pointer showing where one is, and the other showing where one is supposed to go. All the operator has to do is match the two pointers.

An interesting example of how important the knowledge of results can be is provided by data gathered on bombardiers during World War II (*12*). It was found that bombardiers fresh out of school were much superior to the veterans who had made many bombing runs. This result was so contrary to all previous thinking that it took quite a while to convince the "brass" of the findings. In any event, it was decided to establish a retraining course for all bombardiers using simulated runs and electronic scoring methods. Within two months after this program was put into effect aerial photographs established that the veteran had improved in accuracy by a factor of ten. Many other such examples could be cited.

Conclusion

It is hoped that this article will serve as a vehicle for bringing human engineering to the attention of the chemical industry, as well as pointing out a few of the facets of this discipline. Employing the principles of human engineering will pay off in the form of fewer errors and delays, greater production, fewer shutdowns and quicker repairs, and last, but not least, better morale and decreased turnover.

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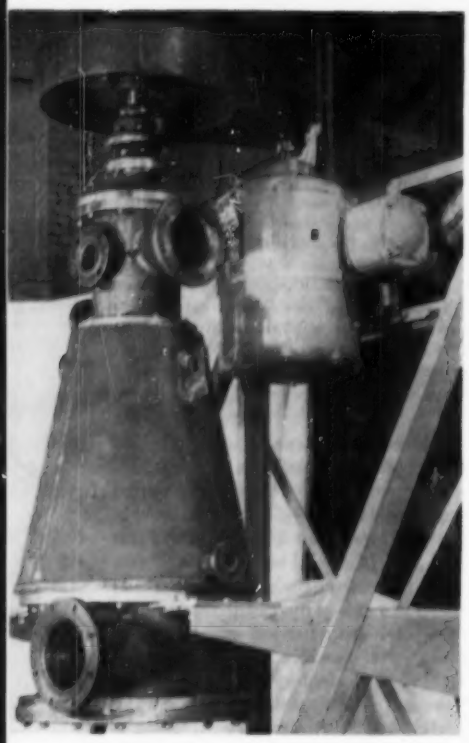

Left, construction photo of centrifugal thin-film processing unit.

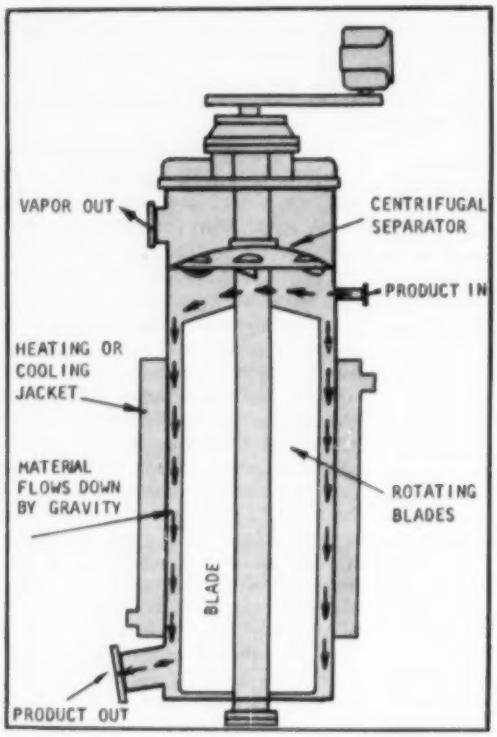

Fig. 1. Schematic drawing of vertical, straight-sided centrifugal thin-film processing unit.

heat transfer in THIN-FILM CENTRIFUGAL PROCESSING UNITS

A new centrifugal device has been developed utilizing the agitated thin-film principle of heat transfer. Rotating blades turning inside a cylinder or a truncated cone develop centrifugal force in the process liquid, causing a violently agitated film to form on the circular wall. By a unique utilization of centrifugal force, fluids can be forced through thin-film equipment just as through a closely spaced concentric-tube heat exchanger. Holdup is small and feed rates control residence time, generally only a few seconds. The role of viscosity, a critical factor in conventional heat transfer, is minimized due to the intensity of the thin-film agitation. Over-all heat-transfer coefficients up to 25-fold greater than normal are claimed.

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Many heretofore difficult processing operations can now be handled commercially on a continuous and closely controlled basis in a newly developed "thin-film" centrifugal processing unit. By a comparison of cost per unit of heat-transfer area only, neglecting processing advantages and high coefficients, agitated thin-film equipment is much more expensive than conventional units. The purpose of this article is to present heat-transfer data so that the engineer can determine the feasibility of this new type of equipment for his particular operations.

Thin-film machines spread the material to be processed centrifugally over a heated or cooled wall in a comparatively thin film, maintained under turbulence with rotating, close-fitting blades. The product flows through the unit by gravity, or by utilizing a portion of the centrifugal force generated.

With a properly designed unit, most operations may be accomplished continuously and automatically in a matter of seconds. Consequently, it is obvious that these machines should be well suited to heat-sensitive materials. Furthermore, because of the short processing time, much higher temperatures are sometimes possible than are feasible in other equipment.

Types of Thin-Film Units

At present there are available three basically different types of centrifugal thin-film units:

1. Vertical, straight-sided fed from the top.
2. Horizontal or vertical reverse taper.
3. Horizontal or vertical forward taper.

The straight-sided design, Figure 1, seems well suited for products of medium viscosity or products of lower viscosity with comparatively high liquid-product discharge rates. This machine is not too well suited for materials of low viscosities requiring a high degree of concentration in a single pass.

Reverse-taper units, Figure 2, have wide load-range characteristics, permitting concentration to a high degree in a single brief pass. These are not intended for very high viscosity products.

Forward-taper machines, Figure 3, develop centrifugal pressure which materially assists in forcing the stock through the unit. Consequently, these are especially suited for comparatively high viscosity materials.

Factors in Heat Transfer

As is the case with most heat exchange apparatus, there are three main stages involved in the transfer of heat in centrifugal thin-film units. The first transfer is from the heating or cooling medium, either condensing or liquid, to the metal wall; the second, through the wall; and the third, from the wall to the material being heated. In contrast to the case with most heat-transfer equipment, the first two phases are important here. This is because the processing side-film coefficients are unusually large in most instances, even though the viscosities at operating temperatures are comparatively high.

Processing side-film coefficients in conventional heat-transfer equipment are dependent on viscosity, turbulence, absolute pressure, and temperature difference. When evaporation or distillation is involved, it is also obviously related to the constantly changing weight or mole fraction of the product being removed.

The effect of fouling on the process side of properly designed thin-film machines appears to be very much less than in conventional heat exchange equipment. This is undoubtedly due to the extremely high turbulence which minimizes or prevents any deposit on the inside surface. Fouling on the outside of the heated or cooled wall is thought to be comparable to that of other heat exchange apparatus operated under similar conditions.

TESTS IN VERTICAL STRAIGHT-SIDED, AND HORIZONTAL REVERSE-TAPERED MACHINES

Heat-transfer tests were made in laboratory-pilot plant size centrifugal thin-film machines of both types. Typical data obtained with water, a low viscosity material, in a vertical straight-sided unit and also in a one-degree reverse-taper machine are summarized in Figures 4 to 7. The steam jackets were well insulated. Only the heat actually transferred was measured. Comparable tests were not run in the forward-tapered machine because of its unsuitability for low viscosity substances.

COMPARISON OF RESULTS

It is evident from the curves that much higher heat fluxes per unit transfer surface were obtained in the reverse-tapered machine at the feed rates used in this study. At higher feed rates, it appears that they would become identical in both machines. In a broad band of feed rates, the tapered-channel unit efficiencies are at a maximum, fixed by thermal saturation of the metal throughout. In the vertical nontapered machine, heat-transfer rate is a linear function of feed rate until thermal saturation of the heat sink is reached. An advantage of the tapered machine is that, by either film thickness adjustment or feed rate control, residence time may be fixed to permit single pass evaporation or distillation processing of product liquid.

Since the two different machines are believed to have approximately the same condensing-steam film coefficients, and the shell walls are of equal thickness and of the same material, it follows that the tapered unit produced superior inside or product-film coefficients.

EFFECT OF VARYING VACUUMS

As indicated in Figure 8, it is generally agreed that over-all heat-transfer coefficients decrease with increas-

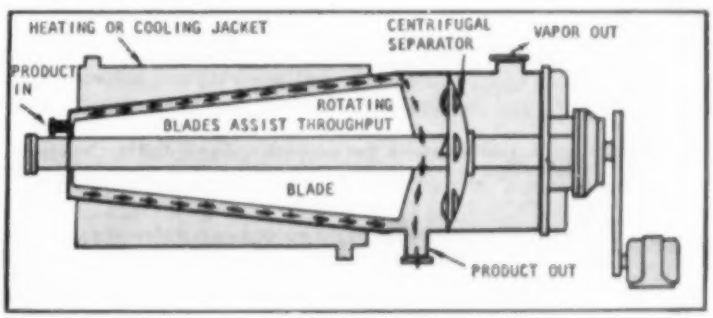
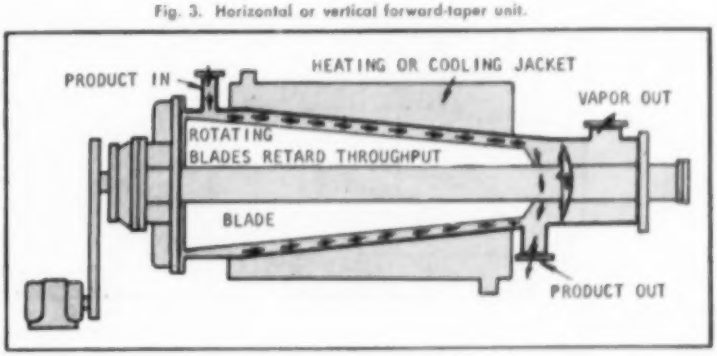


Fig. 2. Horizontal or vertical reverse-taper unit.

Fig. 3. Horizontal or vertical forward-taper unit.



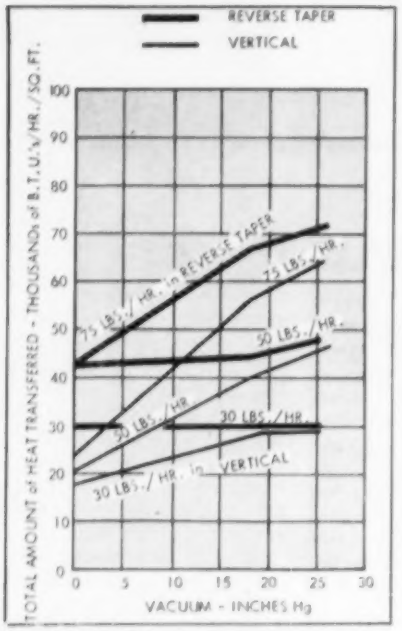


Fig. 5. Relation between vacuum and total amount of heat transferred in vertical and horizontal units at 30 lb./sq.in. gauge steam pressure.

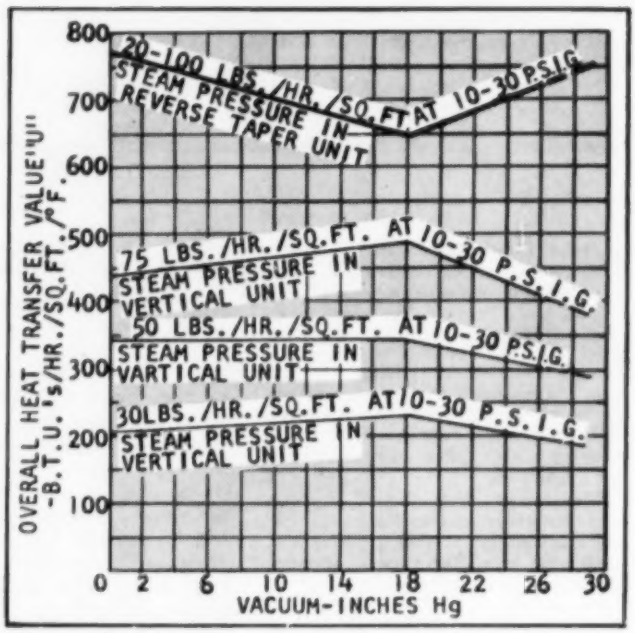

OVERALL HEAT TRANSFER VALUE "U" -B.T.U.'s/HR./SQ.FT./°F.
20-100 LBS./HR./SQ.FT AT 10-30 P.S.I.G. STEAM PRESSURE IN REVERSE TAPER UNIT
75 LBS./HR./SQ.FT. AT 10-30 P.S.I.G. STEAM PRESSURE IN VERTICAL UNIT
50 LBS./HR./SQ.FT. AT 10-30 P.S.I.G. STEAM PRESSURE IN VARTICAL UNIT
30LBS./HR./SQ.FT. AT 10-30 P.S.I.G. STEAM PRESSURE IN VERTICAL UNIT
VACUUM-INCHES Hg

Fig. 6. Relation between vacuum and total amount of heat transferred in vertical, straight-sided and horizontal, one-degree, reverse-taper centrifugal thin-film processing units with water at various feed rates and steam pressures.

ing vacuums in conventional heat transfer equipment—at least with water. This same illustration shows that this is not the case with centrifugal thin-film units. The thin-film data in this graph are the same as those given in Figure 6, except that they have been averaged so as to straighten out the lines.

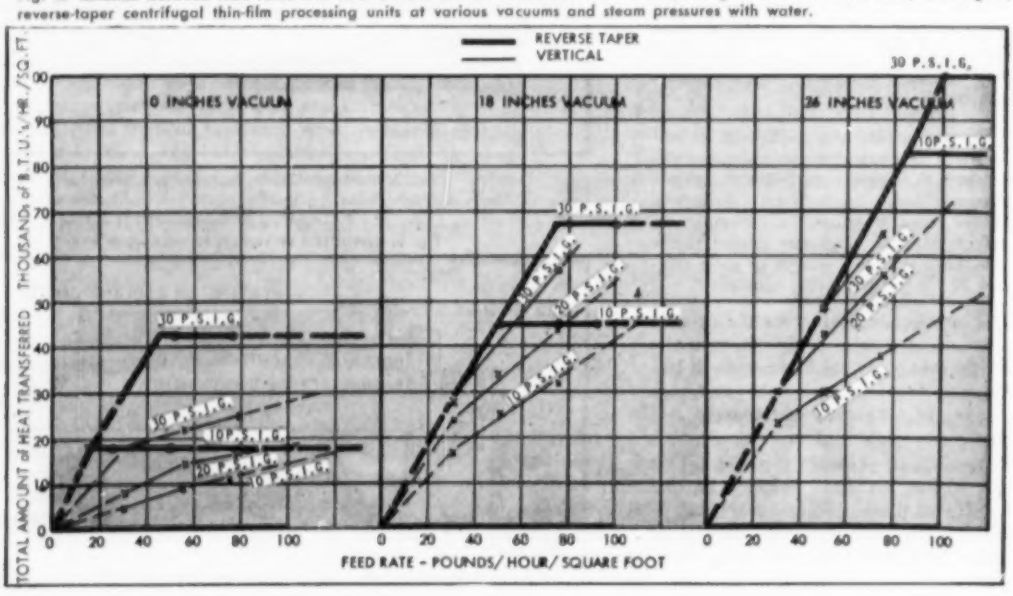
EFFECT OF VARYING DIFFERENCES IN TEMPERATURE

As is also indicated in Figure 8, Badger and Shepard have shown that the over-all heat-transfer coefficient (U), likewise decreases with a drop in ΔT. This is not the case with centrifugal, thin-film apparatus as shown in this same figure. Briefly, and within the confines of the tests, the coefficients are the same in the reverse-taper machine, irrespective of the vacuum, temperature differences, or feed rate. However, variations in the latter factors had a significant influence on heat transfer in the straight-sided machine.

WALL THICKNESS: EFFECT ON HEAT-TRANSFER RATE

Figure 6 shows the over-all heat-transfer coefficient (U) [B.t.u./(hr.)(sq. ft.)(°F.)] at various vacuums. An average value of U for the tapered unit was about 700. Both machines had wall thicknesses of 0.1 in. Assuming a thermal conductivity value k [B.t.u./(hr.)(sq.ft.)(°F.)] of 10 and considering resistance to heat flow in the metal wall only:

Fig. 4. Relation between feed rates and total amount of heat transferred in vertical, straight-sided and horizontal, one-degree, reverse-taper centrifugal thin-film processing units at various vacuums and steam pressures with water.



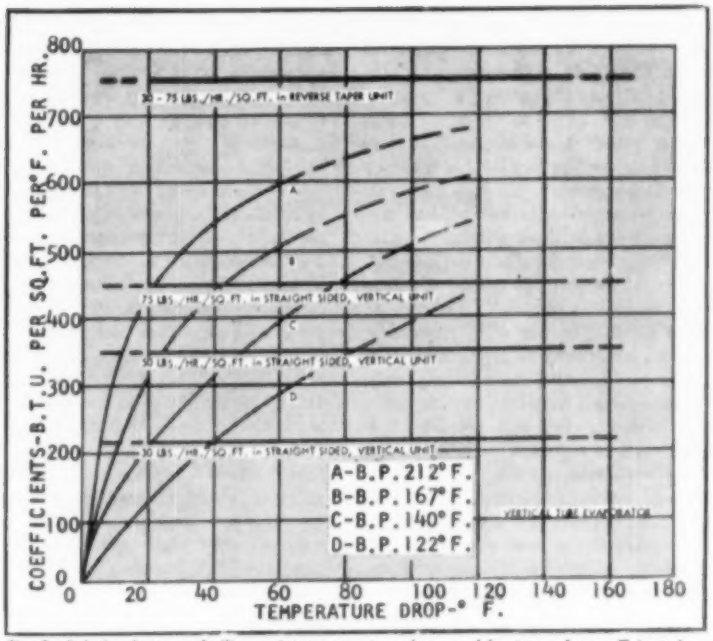

COEFFICIENTS-B.T.U. PER SQ.FT. PER°F. PER HR.
TEMPERATURE DROP-° F.
30 - 75 LBS./HR./SQ.FT. in REVERSE TAPER UNIT
75 LBS./HR./SQ.FT. in STRAIGHT SIDED, VERTICAL UNIT
50 LBS./HR./SQ.FT. in STRAIGHT SIDED, VERTICAL UNIT
30 LBS./HR./SQ.FT. in STRAIGHT SIDED, VERTICAL UNIT
A-B.P. 212° F.
B-B.P. 167° F.
C-B.P. 140° F.
D-B.P. 122° F.
VERTICAL TUBE EVAPORATOR

Fig. 8. Relation between boiling point, temperature drop, and heat transfer coefficients in a vertical tube evaporator * and in vertical, straight-sided and horizontal, reverse-taper centrifugal thin-film units with water at various feed rates.

$$U = k/L^* = 10/0.1/12 = 1{,}200$$

Now, if the steam-film coefficient is assumed to be 2,000,

$$U = \frac{1}{1/1{,}200 + 1/2{,}000} = 750$$

This value is only slightly higher than the values calculated from the tapered-wall unit test data. This indicates that the product-side heat-transfer coefficients were extremely high—at least as high as the steam-film coefficients. It follows, then, that the principal resistance to heat flow in this case is in the metal wall itself.

When the reverse-taper unit receives sufficient feed to permit absorption of all available heat, all the coefficients obtained are at a maximum value which is a constant. Here the processing fluid heat pickup is limited by the maximum heat-transfer rate of which the unit is capable. The straight-sided vertical unit does not reach this critical feed rate except at values so high that recycling is probably necessary. This extra fluid handling is thought undesirable. Below the critical feed rate, the cylindrical machine performs as does a conventional heat exchanger; the steam-film and metal-wall coefficients were identical in each machine. If the cylindrical unit had had film-thickness adjustment, its performance could perhaps have been improved at the feed rates used during this testing.

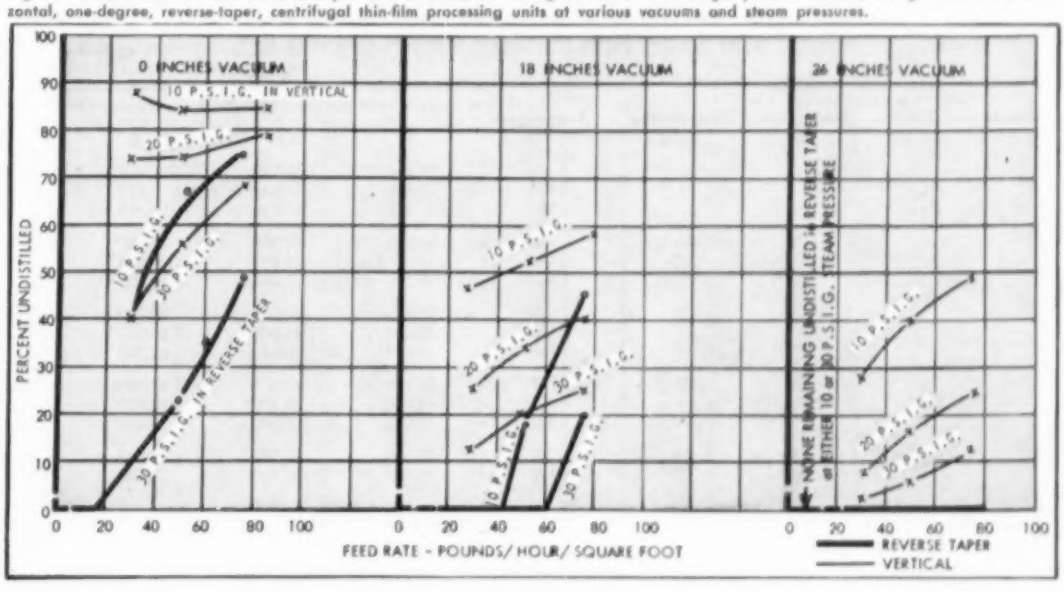
* L = wall thickness, ft.

INFLUENCE OF VISCOSITY

In thin-film machine heat transfer, the role of viscosity, depending on the plastic properties of the process liquid, is usually greatly diminished. Because of the uniquely violent agitation in the thin film itself, the power input of the blades is proportional to fluid viscosity for any particular blade clearance. This power is used to overcome adverse effects of resistance to convective and turbulent fluid flow in the liquid film. In the case of dilatant fluids, the viscosity effect is discernibly deleterious to attainable heat rate.

In appraising the viscosity effect independently, in any type of distillation or evaporization equipment, it becomes difficult to account properly for the effect of concentration taking place. In order to separate this effect, to learn more about viscosity influences, Guar gum, better known as Jaguar, was selected as an agent for further testing. Guar gum, a natural vegetable colloid with an average molecular weight of 220,000, was reasonably well suited for appraising the influence of viscosity

Fig. 7. Relation between feed rates and per cent of water remaining undistilled with single pass in vertical, straight-sided and horizontal, one-degree, reverse-taper, centrifugal thin-film processing units at various vacuums and steam pressures.



on heat transfer in centrifugal thin-film units. For example, ½ per cent of Jaguar increased the viscosity to about 1,000 centipoises; further increase by evaporation to 1½ per cent Jaguar increased this value to about 100,000 centipoises. This mixture exhibited only moderate pseudoplastic characteristics. The use of this material permitted considerable evaporation to be carried out with relatively slight change in mole or weight fraction. Table 1 and Figure 9 summarize typical results obtained with a reverse-tapered unit.

Examination of these data reveals that the over-all heat-transfer coefficients decreased only moderately but uniformly with increasing viscosities up to an actual operating bulk-temperature viscosity of about 10,000 centipoises. Then they began to decrease at a much faster rate to a U value of 350 at 40,000 centipoises. Since U values of 700 were obtained with pure water, this represents a 50% decrease in heat-transfer rate. In such operations, the bulk-temperature viscosity on the blade tips had little effect on the heat-transfer rate up to a 10,000 fold gain in viscosity and further up to 40,000 fold, the effect was not too pronounced. Table 1 shows high shear viscosities of 25,000 to 35,000 centipoises at process bulk temperature. It should be reported that some organic materials have been observed to have delayed setting properties; that is, they do not develop their stagnant equilibrium viscosities instantly upon relief from shear, which is the usual case. Consequently, it is possible that such products could have passed completely through the unit and into the removal system before they had time to develop their high viscosity effects.

Figure 10 depicts heat-transfer rates obtained in a vertical, top fed, cylindrical unit used in concentrating common gelatin at about 140° F. from approximately 25% to 30-40% solids. The U values in the 30% solids vicinity are approximately double those obtained at around 40%. Although complete information is not available on the viscosity in these gelatin runs, the 30% solids product had an approximate maximum viscosity of about 900 centipoises at 140° F. Under the same conditions, the 40% concentrate showed a viscosity of 1,400 centipoises.

Figure 11 shows the relationship between over-all heat-transfer coefficient and viscosity for straight-sided vertical units as reported in the literature. For comparison purposes, the viscosity data given in Figures 9 and 10 are included. Figure 11 also shows that the resistance to heat transfer due to viscosity is less in the tapered unit than in the straight-sided cylinder.

Aspects of Heating Media Selection

STEAM

Process-fluid-side heat-transfer coefficients have been shown to be remarkably high. This results in the highly unusual situation where either the metal-wall resistance or the steam-film resistance to heat flow becomes major or controlling. Where high heat source temperatures are demanded by the process, the heavy design thickness of the steam-jacketed cylindrical wall can become the controlling resistance governing heat-transfer rate. When the cylindrical unit has a diameter of several feet, with even moderately high steam pressures, wall thicknesses can become large and the resistance to heat flow through the wall can become the limiting factor fixing the heat-transfer rate. A similar situation occurs in the case of the more important corrosion-resistant metal walls where extra thickness may have to be added to provide for anticipated corrosion. A recent example involved a cylinder 36 in. in diameter. It was better to design the cylinder to withstand 50 lb./sq.in. gauge steam pressure with a lower ΔT rather than for 150 lb./sq.in. gauge. The increased resistance of the thicker wall of the 150 lb./sq.in. gauge jacket would have reduced the actual heat-transfer rate, despite the considerable increase in temperature difference. If higher pressure steam is mandatory, smaller diameter units can be paralleled. Clad stainless steel with its higher thermal conductivity, may also sometimes decrease wall resistance. Special applications may involve a few extra design considerations.

DOWTHERM

In certain instances, Dowtherm is not suitable as a heat-transfer medium because of its low film coefficients. Very little information on Dowtherm film coefficients for large diameter pipes or cylinders has been observed in the literature. As is shown in Figure 12, it is reported that the Dowtherm film coefficient decreases considerably with increase in cylinder diameter. In the design of thin-film units, maximum heat fluxes are almost always desirable to suit the process and

Table 1.—Viscosities Obtained when Concentrating Water Solutions of Guar Gum *
(One Degree, Reverse-Taper, Centrifugal Thin-Film Processing Unit)

Processing Conditions					Viscosity **			
					Spindle rev./min.			
Concentration %	Vacuum In. Hg	Temperature ° F.	Concentration Ratio	Temperature ° F.	1	2	5	10
0.65*	..	...	....	81	1,280	1,280	1,150	1,020
"	..	...	....	138	600	640	515	510
"	..	...	....	166	375	350	384	320
1.3	18	168	2.0	68	14,800	11,800	8,000	6,000
"	"	"	"	138	4,500	3,850	3,200	2,800
"	"	"	"	165	3,200	2,600	2,300	2,000
1.52	18	171	2.3	68	100,000	68,000	38,000	23,000
"	"	"	"	140	51,000	38,500	26,000	18,000
"	"	"	"	166	51,000	38,500	23,700	16,500
1.78	26	135	2.7	82	86,500	64,000	41,000	27,500
"	"	"	"	136	45,000	36,800	27,000	19,500
"	"	"	"	165	32,000	27,500	20,500	15,700
1.90	26	135	2.9	82	122,000	87,500	52,500	35,000
"	"	"	"	136	60,000	51,500	36,500	26,000

* Stein, Hall & Co., Inc., Jaguar.
** Brookfield in centipoises.
* Unprocessed starting material.

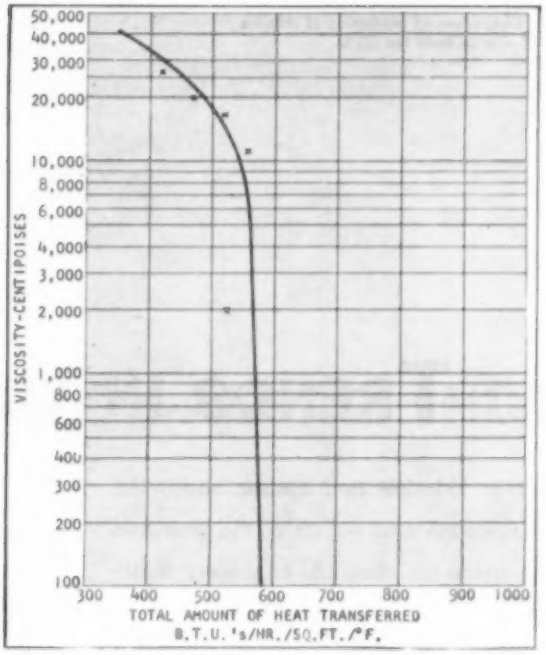


Fig. 9. Relation between total amount of heat transferred in B.t.u./(hr.)(sq.ft.)(° F.) and viscosity in centipoises at operating temperature when concentrating water solutions of guar gum in range 0.5-2.0% in one degree, reverse-taper centrifugal thin-film unit.

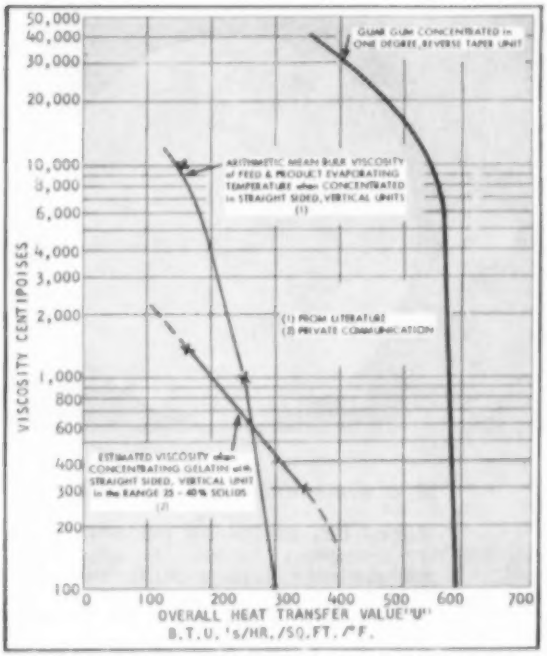

GUAR GUM CONCENTRATED in ONE DEGREE REVERSE TAPER UNIT
ARITHMETIC MEAN BULK VISCOSITY of FEED & PRODUCT EVAPORATING TEMPERATURE when CONCENTRATED in STRAIGHT SIDED, VERTICAL UNITS (1)
(1) FROM LITERATURE
(2) PRIVATE COMMUNICATION
ESTIMATED VISCOSITY when CONCENTRATING GELATIN with STRAIGHT SIDED, VERTICAL UNIT in the RANGE 25 - 40% SOLIDS (2)
VISCOSITY CENTIPOISES
OVERALL HEAT TRANSFER VALUE "U"
B.T.U.'s/HR./SQ.FT./°F.

Fig. 11. Relation between viscosity and total amount of heat transferred for various materials concentrated in centrifugal thin-film equipment.

also to cut down capital costs. Frequently the high resistance to heat flow of the Dowtherm film prohibits its use. Nevertheless, many Dowtherm operations are primarily concerned with obtaining the higher temperature and only moderate amounts of heat may need to be transferred.

AROCLOR

Among the many heat-transfer liquids, Aroclor stands out as a high temperature medium with low vapor pressures up to and over 600° F. Its over-all heat-transfer coefficient is reported to be 469 at 600° F. measured through a 0.81 in. I.D. tube at 12 gal./min. The vapor pressure at 600° F. is only 350 mm. Hg. Therefore the previously described limitations of wall thicknesses, heavy jackets, etc., and their resultant higher construction costs can sometimes be obviated.

Miscellaneous Over-all Heat-Transfer Coefficients

Substantially lower over-all heat-transfer coefficients are normally obtained in processing organic materials in conventional heat-transfer equipment than when aqueous products are processed at comparable conditions. This phenomenon was not observed when low viscosity products were processed in the reverse-tapered unit. Typical data are tabulated below:

Substance	U[B.t.u./(hr.)(sq.ft.)(° F.)]
Acetic Acid	745
Fatty Acids	330
Isopropyl Alcohol	400
Methyl Alcohol	650
Water	700

Presented at joint A.I.Ch.E.-A.S.M.E. Heat Transfer Conference, State College, Pennsylvania.

Fig. 10. Relation between total amount of heat transferred and concentration and viscosity when concentrating gelatin in straight-sided vertical unit (1).

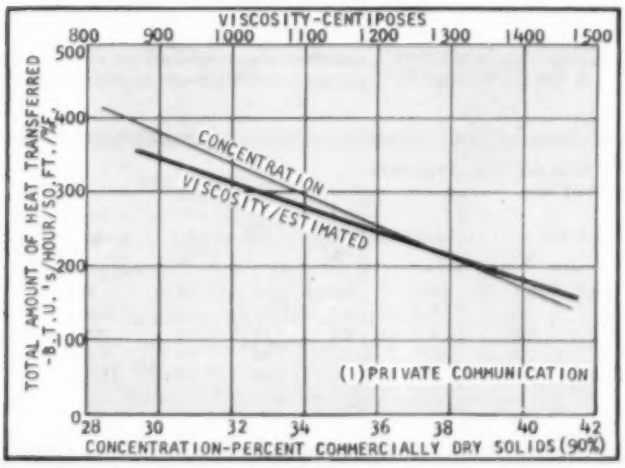
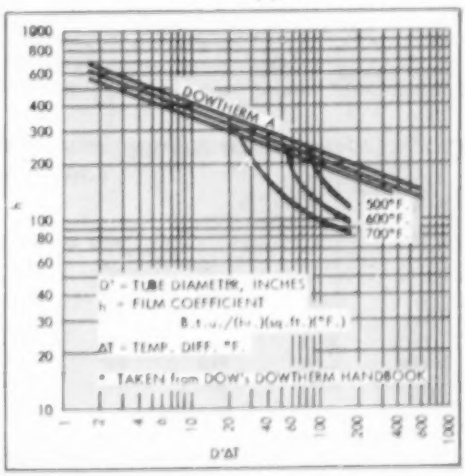


Fig. 12. Condensing film coefficients in Dowtherm outside horizontal pipes.



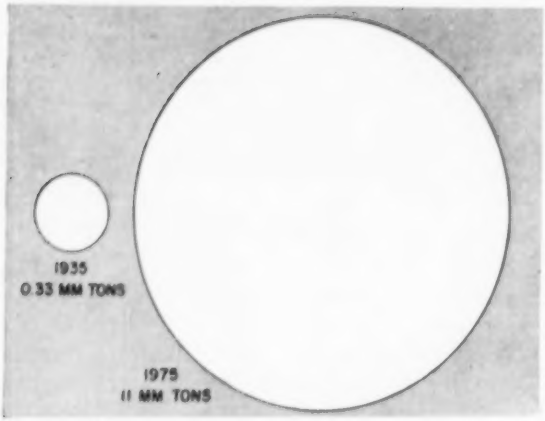


Fig 2. Comparison of production of chlorine in 1935 and estimate for 1975.

TRENDS IN THE

In a presentation of an analysis on trends in chlorine and caustic soda, the author has assembled pertinent facts on the growth and outlets of the past and the present. Such a study may serve as a guide for chemical engineers' thinking on these subjects for the years ahead.

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Diamond Alkali Company,
Painesville, Ohio

In charting future consumption patterns of the chlor-alkali industry, one can assume that the economic health of the nation of the past several years will continue, that peace will prevail, and that sweeping new concepts of technology that might reorient chlorine's position in the chemical industry shall not arise. If these generalities can be made, broad trend patterns in chlor-alkali use may be offered.

Use of chlorine in synthetic organic chemical manufacture has absorbed increasing tonnages and percentages of total chlorine production annually. This trend is expected to continue. Figure 1 depicts the growth rate of synthetic organic chemicals with indications of leveling somewhat during the next twenty years in contrast to the 1935 to 1955 era. If a curve is drawn for chlorine production similar to that for synthetic organic chemicals, about 7.4 million tons of chlorine may be expected in 1965 and about 11 million in 1975. With 81% of chlorine production (1955) and an estimated 88% in 1975 entering chemical manufacturing, such an approach may give a more realistic estimate for chlorine growth than would variable increments or a Gompertz curve with its forecast of about 19 million tons for 1975.

In Figure 2 the relationship between 0.33 million tons chlorine produced in 1935 is compared with the forecast 11 million tons for 1975. The area of a circle drawn for the production of 1925 would be about ⅓ that for 1935. In a study of the end-uses for chlorine and caustic soda, shifts will be traced in consumption from 1935 through 1955 with projected trends to 1975.

For convenience, five classifications are reviewed in Figure 3: chemicals and related products, such as metals, pulp and paper, sanitation, cotton textiles, and net exports. The greatest growth is expected in chemical usage

* Mr. Sheets is staff assistant, Electro Chemicals Division, Research Department.

Table 1.—Trends in Chlorine Use—1935-1975
(M short tons)

	Chemicals	%	Pulp & paper	%	Sanitation	%	Cotton textiles	%	Net exports '	%	Total production
1935	161	48.8	109	33.0	35	10.6	19	5.8	6	1.8	330
1955	2,745.5	80.6	510	14.9	117	3.4	5.5	0.2	30	0.9	3,408
1956	3,113	82.3	527	13.9	122	3.2	4	0.1	19	0.5	3,785
1965	6,400	86.5	800	10.8	155	2.1	(7)*	(<0.1)*	45	0.6	7,400
1975	9,640	87.7	1,100	10.0	200	1.8	(10)*	(<0.1)*	60	0.5	11,000

' Net exports = exports minus imports.
* Absorbed in chemicals.

CHLOR-ALKALI INDUSTRY

Use of chlorine in chemical manufacturing will tend to grow more slowly after 1965 when functioning more closely with synthetic organic chemical needs is anticipated. In view of expansions in the pulp and paper industry, enlarging use of chlorine for bleaching appears assured. To service an increasing population with its rising per capita consumption of water coupled with larger waste disposal facilities, additional chlorine will be needed for sanitation in safeguarding the nation's health. These data are presented in tabular form in Table 1.

On a percentage basis, pulp and paper as well as sanitation will decline somewhat, although tonnages of chlorine entering these outlets will continue to increase.

In the future, usage of chlorine for bleaching cotton is expected to become modest.

Increased product... from foreign chlor-alkali plants will tend to offset any possible significant gains in the export market.

In 1935 the per capita consumption of chlorine in the U. S. was about 3.5 lb.; in 1955 this value came near 41.0 lb.; by 1965, this estimate should approach 77 lb.; by 1975, 100 lb.

Table 2 reviews tonnages of chlorine used in 1956 for the manufacture of certain chemicals.

Table 3 presents similar data for 1955. The increase in production of many of these chemicals from 1945 vs. 1955 is indicated.

Chlorinated Solvents

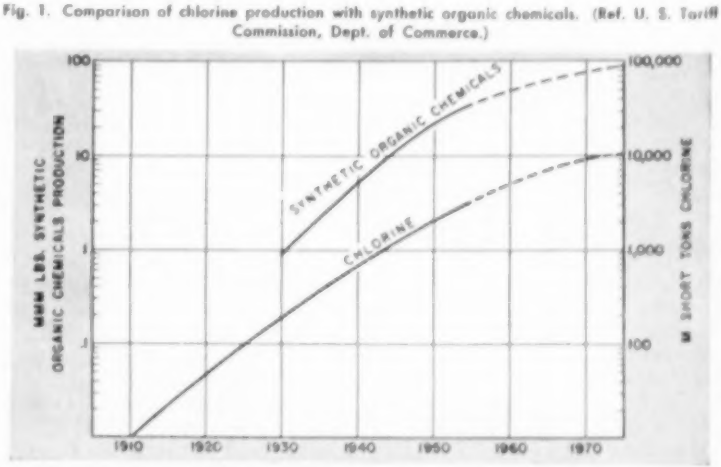
The striking growth rate in chlorinated solvents is expected to moderate in the future. Use of trichloroethylene will probably follow demands in metal finishing for vapor degreasing. Perchloroethylene has eclipsed carbon tetrachloride as a dry-cleaning solvent owing to its less toxic properties, with expansion expected as naphtha-plant owners in the industry continue their switch to synthetic systems. Additional tonnages are expected to enter metal-degreasing applications. The future of carbon tetrachloride seems linked with increasing production of fluorinated hydrocarbons. Confidence in the refrigerants and propellant market is expressed by the erection of new facilities by the chemical industry. Further encroachment by other chlorinated solvents such as chloroform and methylene chloride, and by petroleum gases such as butane, is expected. The demand for methyl chloride for manufacturing butyl rubber and silicone resins and for methylene chloride-based paint removers has sparked a swelling consumption for these chlorinated methanes. The rise in production of these solvents from 73 million in 1935, 483 million in 1945 to 906 million pounds in 1955 requiring 647 thousand tons chlorine, 19% of total 1955 chlorine production, emphasizes the importance of the solvent outlet.

Since the advent of the first direct oxidation ethylene oxide plant in 1937, there has been a shift industrywise toward this route. Direct oxidation accounts for about 52%, chlorohydrin 48% of today's estimated 1.18 billion pounds ethylene oxide capacity. Although current expansions continue to favor direct oxidation, the chlorohydrin route still has its adherents as exemplified by an additional 60-million pound facility soon to be erected. The gains in sales for ethylene glycol

STATISTICS

The growth of chlorine from 1910 through 1956 averaged 13.8%/yr. From the period 1935 to 1955 inclusive, it was about 12%, and from 1950 to 1956 inclusive, this growth approximated 10½%/yr. The more recent trend indicates an adjustment in chlorine expansion for the years ahead.

Fig. 1. Comparison of chlorine production with synthetic organic chemicals. (Ref. U. S. Tariff Commission, Dept. of Commerce.)



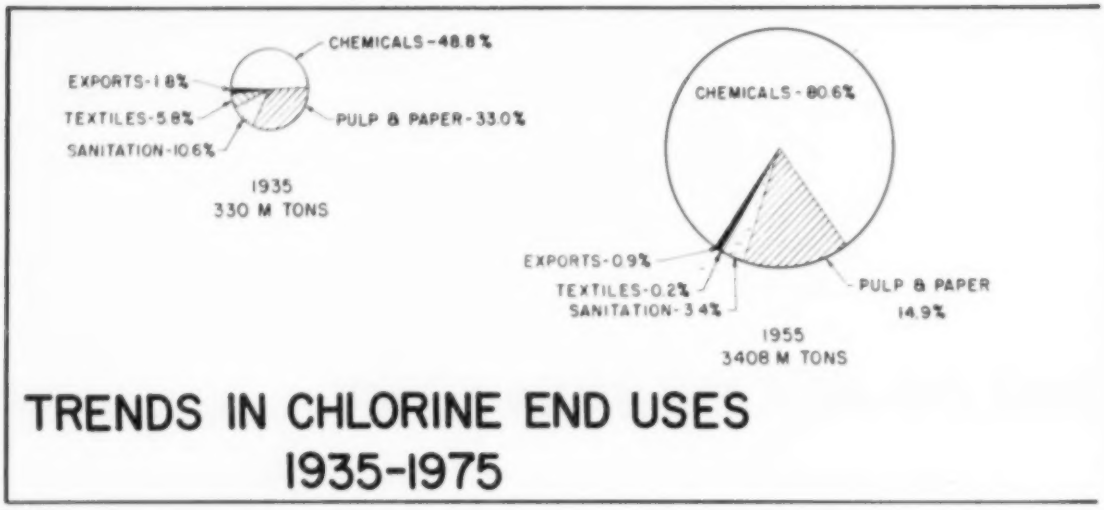


Fig. 3.

Table 2.—Estimated Use of Chlorine in the Manufacture of Certain Chemicals and Related Products
(1956)

	M short tons chlorine used
Solvents	
Trichloroethylene	190
Perchloroethylene	160
Carbon tetrachloride	240
Intermediates	
Ethylene oxide	330
Monochlorobenzene	160
Ethylene dichloride	200
Insecticides	
DDT (partial duplication of MCB)	92
BHC	34
Pentachlorophenol	6
Inorganic	
HCl (synthetic)	176
Titanium (metal)	56
Aluminum chloride (anhydrous only)	29
Others	
Glycerin	138
Vinyl chloride	200

plus rising demand for surfactants, acrylonitrile, and ethanolamines, will continue to be an important chlorine consumer but will decline percentagewise of total ethylene oxide produced.

If the advent of gas turbine or free-piston-powered cars and trucks materializes in volume as expected, sometime during the next two decades, consumption of automotive fluids as a consumer of chlorine will be significantly altered. For 1965, present estimates of about 950 million pounds ethylene oxide will be employed for the manufacture of ethylene glycol, 70% of which may be sold for antifreeze. For the same year 530 million pounds ethyl chloride (equivalent to 166 thousand tons chlorine) to manufacture an estimated 600 million pounds tetraethyl lead plus another 100 thousand tons chloride as ethylene dichloride may be used in compounding ethyl fluid.

Substantial quantities of ethylene dichloride, as an intermediate are used in vinyl chloride monomer production. The hydrochlorination of acetylene is an alternate route. Production in 1956 of vinyl and copolymers resins, the No. 1 plastic, was almost 650% more than production in 1945. On a vinyl chloride monomer basis, 1956 production was about 600 million pounds. Further enlarging consumption of this important chlorine outlet may be expected in the construction industry, in floor tile, coating textile goods, and in electrical insulation.

Chlorine

Although only 2,000 tons chlorine were used for phosgenation of amines in 1956, inplace capacity once utilized fully should employ 32 thousand tons chlorine, more when future markets planned for urethane foams near fruition. Vinylidene chloride, that portion of phenolics using the monochlorobenzene route, neoprene, and chlorinated rubbers, are other resin outlets. Smaller volume resins with varying growth potentials include Kel F, chloroacrylates, and chlorinated polystyrenes. Demand for chlorinated wax has declined since its World War II flameproofing experiences but a modest increased employment is expected in the future. Expansion of nylon 66 facilities by nine million pounds in 1956 and a further 55-million pound addition earmarked by 1958, plus other possible new intermediate salt production, will command greater tonnages of chlorine or high purity hydrogen chloride where such routes as the chlorination of butadiene or tetrahydrofuran to dichlorobutane are selected.

INSECTICIDES

Almost twice as much monochlorbenzene was manufactured in 1955 vs. 1945, heralded by increasing consumption in such insecticides as DDT, the dichlorobenzenes, and larger demands from part of phenol and aniline manufacture. Further needs of MCB will probably follow expansion of these market patterns.

Propylene oxide, made by the chlorohydrin and oxidation routes, is expected to recapture loss in antifreeze use by rising demands for esters, resins, and hydraulic fluids by 1960.

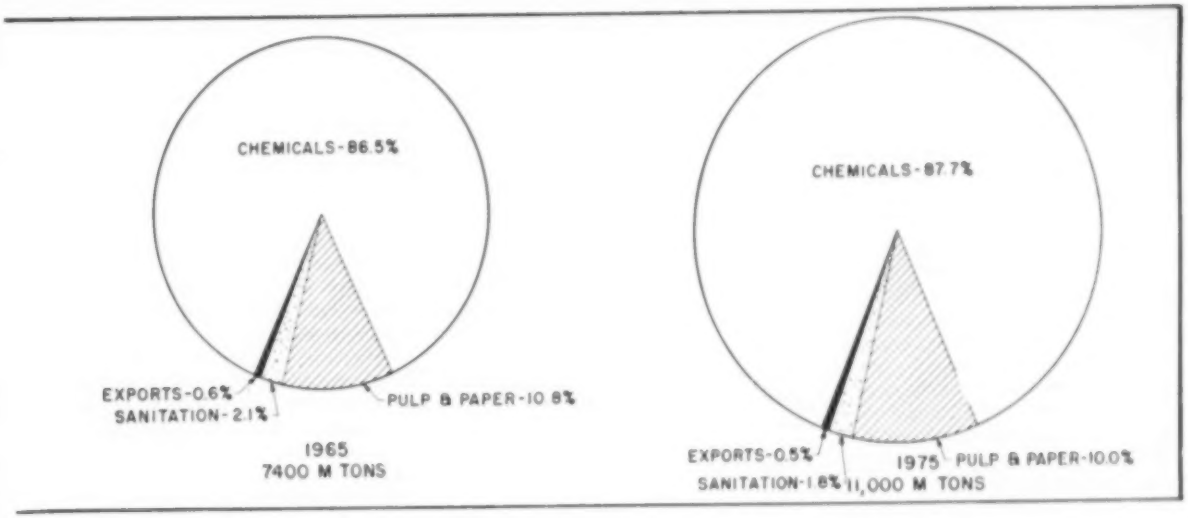
Chlorinated xylenes offer promise as an intermediate for polyesters.

The future of benzenehexachloride appears linked with more effective methods of application and use since boll weevils have developed resistance to benzenehexachloride in certain areas. Lindane has been a trade disappointment. Pentachlorophenol in service for wood preservation is becoming more popular.

Other chlorinated pesticides include toxaphene, chlordane, methoxychlor, dieldrin, aldrin, heptachlor, TDE, 2, 4 D, and 2, 4, 5 T.

DDT continues to lead in the production of insecticides with greater use being directed against corn borers and for aerial treatment of tracts of woodlands. About half U. S. production in 1955 entered world markets.

Increased quantities of chlorine are expected in the future for the manufacture of chlorinated nematocides,



such as DD, terrachlor, chloropicrin, and others, and miticides such as ovex, sulfenone, chlorobenzilate, when these preparations are more fully merchandised. Other promising pesticides combine chlorine and phosphorus, such as DDVP, ET 14 and 15, and chlorthion.

Increasing production of titanium sponge and, concurrently, its use of chlorine in the preparation of tetrachloride are expected to soften somewhat in the immediate future, while civilian markets, encouraged by easier methods of fabrication and new alloys, are exploited more fully.

As 95% of titanium has been used for military aircraft, adjustments in defense needs are felt very quickly. A portion of the nation's titanium oxide pigment production is made via the chlorine route.

Committed production for the A.E.C. for the next five years of eleven million pounds zirconium will absorb a probable 11,400 tons chlorine. A portion of the chlorine used for titanium and zirconium tetrachloride production is recovered by electrolysis, then recirculated. Continuation of titanium's phenomenal rise in consumption is contingent upon accelerating defense purchases. High purity silicon is made from the tetrahalide also.

Synthetic hydrogen chloride production has doubled between 1945 and 1955 primarily for high purity requirements, registering a slight gain, percentagewise, of total hydrogen chloride made by all methods.

SYNTHETIC GLYCERIN

Production of synthetic glycerin has been rapidly overtaking the natural product and with a further increase of 35 million pounds by the allyl chloride method next year, about 47.5 thousand tons additional chlorine should be used. The alternate hydrogen peroxide-acrolein route may abridge further linear needs for chlorine in glycerin in the years ahead.

Chlorine is being used in larger volume to volatilize impurities in aluminum and in ferroalloys. Sodium hypochlorite is expected to continue its popularity as a household germicide. Other chemicals requiring chlorine include monochloroacetic acid, ferric chloride, chlorinated toluols, and phosphorus trichloride.

Further growth of chlorine in chemical manufacturing is based upon the expansion of most current end-uses, plus the exploitation of new products now venturing upon the scene and others expected within the next twenty years. Anticipated adjustments in markets for organic chemicals will be sensitively reflected by appropriate revisions in future chlorine production.

About 22% of the 1955 five million tons of pulp production was bleached sulfite and bleached and semibleached kraft. This expanding outlet for chlorine is emphasized by production of 5.5 million tons or 26.7% of these pulps of the 20.7 million tons total pulp production in 1955. This trend toward the manufacturing of more bleached pulp is expected to continue with a forecasted 29.6% in 1960 of 29.3 million tons pulp capacity being from bleached or semibleached sulfite, sulfate, and semichemical pulps.

Imports of pulp from abroad have held across the last twenty years between 1 and 2½ million tons, which assures larger markets for domestic chemicals production.

Estimates for 1965 of wood pulp production of 32 million tons is expected to use 800 thousand tons chlorine, and by 1975, 39 million tons pulp, 1.1 million tons chlorine.

Since chlorine dioxide has a lower oxidation potential than hypochlorite with resulting less degradation of fibers, it is expected to become more popular, particularly in the finishing stage of multibleaching sequences.

SANITATION

Sanitation has been a steadily growing user of chlorine. Percentagewise this outlet is not so important to total chlorine usage as it was twenty years ago, but its function in safeguarding the nation's welfare ranks this service above any dollar considerations. It is expected that at least 155 thousand tons will be needed for sanitation in 1965, 200 thousand tons by 1975. Perhaps 65% of this amount will enter municipal and industrial water plants with modest quantities for swimming pools. The balance will be purchased for sewage disposal and industrial wastes treatment. Challenges from ozone, ultraviolet lights, and bromination for treating water is not expected in this country.

Bleaching cotton goods with chlorine has been primarily supplanted with peroxides.

Exports are not expected to become a significant factor in the end-use pattern.

Other methods for producing chlorine which do not yield by-product caustic soda tender annual statistics much different ratios from an anticipated stoichiometric 1.13 tons caustic soda/ton chlorine. Production of metallic sodium primarily for TEL, for reduction of titanium tetrachloride, metal descaling, and miscellaneous uses produced 5½% of 1956's chlorine production. Other coproducts of chlorine are potassium hydroxide and lithium. Synthetic sodium nitrate is made by the nitrosyl chloride method. Broader experience with reactive sodium amalgam for compounds other than caustic appears certain.

Caustic Soda

Table 4 estimates the production of 7.6 million tons caustic soda is probable in 1965 and 11.2 million in 1975. Market pressure is expected to reduce production of lime soda caustic soda to 100 thousand tons in 1965, and possible elimination altogether sometime afterwards.

Figure 4 cites trends in caustic soda. Unlike chlorine consumption, which is sometimes used as a gauge for a nation's standard of living, caustic soda is a necessity among backward peoples as well as among the progressive ones. This versatile alkali is used in varying quantities by almost every facet of the industrialized economy.

Preference by industry for the more easily handled liquid forms is seen by 75.4% of total caustic soda production in 1945 increasing to an estimated 87% put to use in 1955 as liquor. During this decade production of anhydrous material statically fluctuated between 450 and 650 thousand tons.

Examination of per capita consumption of caustic soda and soda ash shows an increasing preference for caustic soda. During 1930-1935 a mean of 1 lb. caustic soda was employed for each 3.6 lb. ash; 1940-1945, 1 lb. caustic soda for every 2.8 lb. ash; 1950-1955, 1 lb. caustic soda for every 1.6 lb. ash (all years inclusive).

Outlets showing wider application, apart from linear requirements following general economic growth and a rapidly increasing population, include chemicals, pulp and paper, cellophane, and further new metallurgical examples.

A listing of certain chemical end-uses is given in Table 5. The utilization of caustic soda by the chemical industry has expanded almost a hundred times between 1935 and 1955. By 1965, 31% of caustic soda production and in 1975, 36% may be used for chemical manufacturing. Substantial quantities of alkali as in phenol production are used captively by the industry.

In 1955, about 10 thousand tons caustic soda was used in synthetic ethanol production. Were all the chlorination and sulfonation capacity utilized that year in phenol production, 284 thousand tons caustic soda would have been required.

A delineation of caustic soda markets appears in Table 6. Although the production of 973 million pounds viscose rayon in 1955, almost 170% over 1945, and 470% over 1935 was at an all-time high, indications of maturity have appeared. This trend may be neutralized by such recent developments as the production of staple with enhanced strength and other improved physical properties signaling possibilities, through research and vigorous merchandising, for further growth of all types viscose rayon in 1975 to perhaps 1.4 billion pounds. Four and one-half times caustic soda was used for rayon and film production in 1955 vs. 1935 in face of improved chemical-recovery systems.

Cellophane production continues to mount in face of vigorous competition of polyethylene, styrene, and foils, and is expected to remain dominant in packaging with the estimated production of 325 million pounds in 1955, five times that of 1935. Additional capacity such as the 50-million pound plant in Tecumseh, Kansas, augurs further expansion for the probable 600 million pounds in 1965 and 780 million in 1975 during both decades about 4% of caustic-soda production entering this outlet.

Table 4.—Comparison of Chlorine Production with Caustic Soda

(M short tons)

	1935	1955	1965	1975
Production of chlorine	330	3,408	7,400	11,000
Production of caustic soda				
Electrolytic	316	3,439	7,500	11,200
Lime soda	428	466	100	0
Caustic soda—total	744	3,905	7,600	11,200

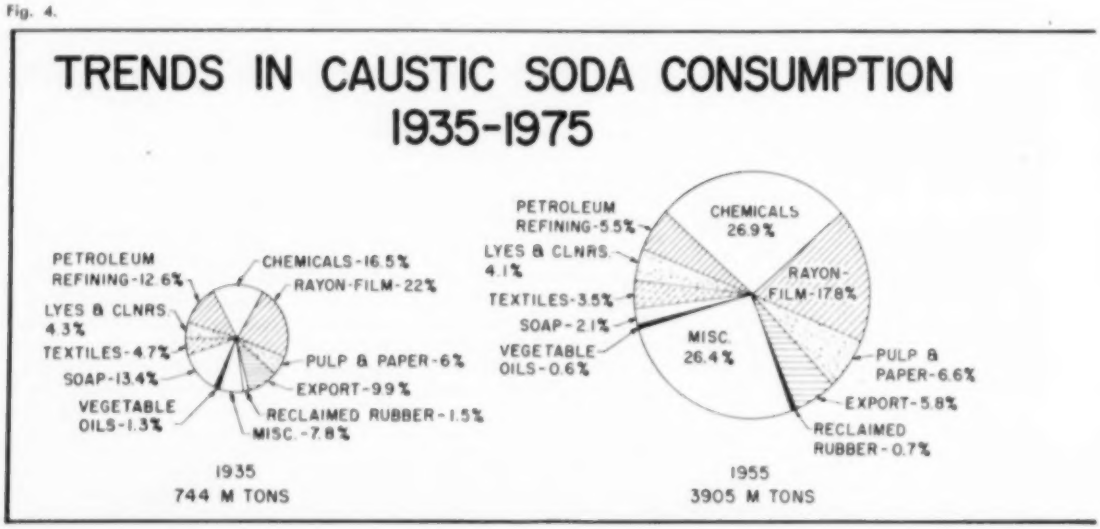
Table 5.—Certain Chemical Uses for Caustic Soda

(M short tons)

Chemical	1956
Glycerin	62
Pentaerythritol	16*
Cresylic acid and cresols	15
Ethylene glycol	10
Formic acid	7
Trisodium phosphate	6
Toluol (coal tar)	5
2, 4 D	7

* = Basis: 100% usage of caustic soda.

Fig. 4.



Growth of caustic soda consumption in pulp and paper is expected to expand not only with increases in industrial capacity but by new uses as exemplified by the alkaline-mechanical pulping of hardwoods, particularly for groundwood. This added market, if it comes near fruition, should demand 60 thousand tons caustic soda of the estimated usage of 1965 of 480 thousand tons in the production of wood pulp, paper, and paperboard. In 1975, this added market could reach 80 thousand tons of a total of the year's 680 thousand tons.

Substantial quantities of chlorine and caustic soda needs will continue to be supplied by inplace captive chlor-alkali capacity in pulp mills.

Greater consumption of caustic soda in future world markets will be met to a larger extent by enlarging foreign capacity with accompanying greater competitive pressure in the market.

Caustic soda usage by the petroleum industry in 1955 was 2½ times that of 1935. Broadened internal usage in refineries is not probable with modest encroachment by caustic potash expected for sulfur removal. The expected growth in multiple ownership of automobiles, plus rising population requiring more fuel, may heighten demand of caustic soda to 460 thousand tons or more by 1975, this statistic on the assumption that gasoline consumption patterns continue present growth rate.

Lyes and cleaners have maintained a level of caustic soda usage slightly above 4% from 1935 to 1955. Consumption patterns are expected to follow general levels of industrial activity. About 3½% of caustic soda production may enter this market in 1975.

Use of caustic soda for kier boiling

Table 6.—Trends in Caustic Soda—End-Use

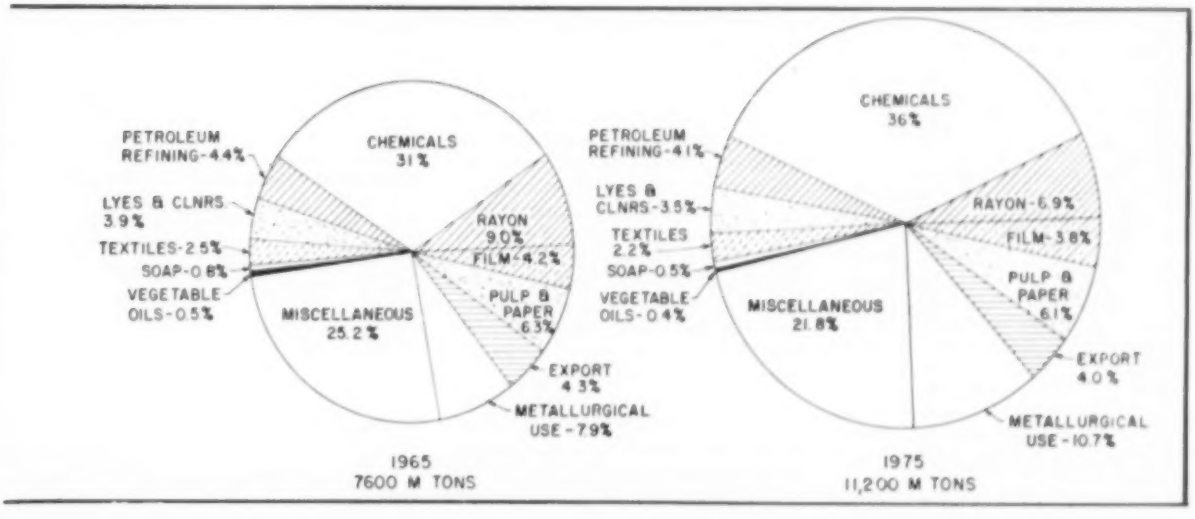
(M short tons)

	1935 (1)		1955 (2)		1965		1975	
Chemicals	118	16.5%	1,050	26.9%	2,350	31.0%	4,000	36.0%
Rayon	158	22.0	695	17.8	680	9.0	780	6.9
Film					320	4.2	420	3.8
Pulp and paper	43	6.0	258	6.6	480	6.3	680	6.1
Export	71	9.9	227	5.8	330	4.3	450	4.0
Petroleum refining	90	12.6	215	5.5	335	4.4	460	4.1
Lyes and cleaners	31	4.3	160	4.1	295	3.9	390	3.5
Cotton textiles	34	4.7	137	3.5	190	2.5	250	2.2
Soap	96	13.4	82	2.1	60	0.8	55	0.5
Reclaimed rubber	11	1.5	27	0.7	10	0.1	...	...
Vegetable oils	9	1.3	24	0.6	35	0.5	45	0.4
All others (including metallurgical uses)	55	7.8	1,030	26.4	2,515	33.0	3,670	32.5
Metallurgical uses					(600)	(7.9)	(1,200)	(10.7)
Total production	716		3,905		7,600		11,200	

Table 3.—Estimated Use of Chlorine in the Manufacture of Certain Chemicals and Related Products

(1955)

% increase of production 1945-1955	Chemical	M tons chlorine used
	Solvents Total	647
170	Trichloroethylene	175
300	Perchloroethylene	154
140	Carbon Tetrachloride	227
425	Chloroform	31
120	Methyl Chloride	27
680	Methylene Chloride	33
	Intermediates	
450	Ethylene Oxide	310
185	Monochlorobenzene	157
220	Ethyl Chloride	165
340	Ethylene Dichloride	196
	Monochloroacetic Acid	20
	Chlorinated Aromatics	
	Trichlorophenol	2
	Trichlorobenzene	8
	Benzyl Chloride	4
	Insecticides	
	Benzene Hexachloride	24
220	o-dichlorobenzene	11
210	p-dichlorobenzene	23
380	DDT	83
	2, 4.5 T	1
	2, 4 D	20
	Pentachlorophenol	5
	Inorganic	
200	HCl (synthetic)	150
	Titanium Metal	30
172	Aluminum Chloride (anhydrous only)	29
	Bromine and compounds	42
	Resins	
	Vinyl Chloride	175
	Chlorinated Paraffin	17
	Others	
	Glycerin (synthetic)	128



and mercerizing for cottons is expected to continue and probably linearly with total broad woven goods production expected to approach 7 billion pounds in 1975. At that time natural fibers may be overshadowed by preponderant usage of synthetics.

The perennial decline in soap production currently shows tendencies to moderate for the future. Although 1935's caustic soda market was 13.4% for soap, 1955 saw this drop to 2% and may decrease to 0.5% in 1975. This shift towards detergents is not a total market loss for caustic soda inasmuch as caustic is used in the synthesis of many syndets, as in the neutralization of excess sulfuric acid for dodecyl benzene sulfonate manufacture.

Use of caustic soda in defiberizing rubber has declined with a shift toward neutral baths of $CaCl_2$ and $ZnCl_2$ or by mechanical milling since the advent of synthetic rubber and mixtures of synthetics with natural.

Caustic soda is used to precipitate uranium in alkaline leaching of its ores.

The lye peeling of vegetables and fruits is a minor caustic soda use showing promise of modest expansions using an estimated nine thousand tons in 1955.

Where chlor-alkali producers are faced with regional surpluses of caustic soda, increased tonnages can be carbonated to service the needs of ash users.

Table 7 displays the end-use pattern for 1956. Chlorine's promise for the future lies with expanding technological advances for larger chemical applications. Appropriately, larger percentages of chlorine are expected to be used captively by chlor-alkali producers.

Caustic soda will base its growth upon familiar end-uses in well-delineated fields with swelling advances in industrial chemicals, pulp and paper, and new markets in metallurgy.

To avoid possible imbalances between caustic soda and chlorine, further new uses for both products must be developed.

Table 7.—Caustic Soda End-Use—(1956 estimate)

End use	Tons/day	M tons/yr.	Approximate % of total
1. Chemicals	3,070	1,120	26.6
2. Rayon	1,310	478	11.3
3. Film	643	176	4.2
4. Pulp and paper	844	307	7.3
5. Net export (exports-imports)	703	257	6.1
6. Petroleum refining	624	228	5.4
7. Lyes and cleaners	470	172	4.1
8. Textiles	370	135	3.2
9. Soap	210	77	1.8
10. Vegetable oils	80	29	.7
11. Reclaimed rubber	36	13	.3
12. All others	3,340	1,220	29.0
TOTAL	11,700	4,212	100.0

Although vegetable oils have been beset with government quotas, declining margins, and other uncertainties, worldwide shortages and U. S. needs should broaden this tonnage usage of caustic soda for the future.

Within the "all others" classification has been included a review for metallurgical uses which has promise of fast becoming a major market for caustic soda. It has long been a well-known fact that alkalis such as soda ash and caustic soda used alone or modified with other materials are excellent agents to control minor but important constituents in steel such as sulfur and silicon. Engineers have only recently been successful in designing equipment to perform this perplexing task. High sulfur content coke should, therefore, be of less concern to quality-conscious blast-furnace operators and ferrous foundrymen. Other growth metallurgical outlets include alumina extraction and digestion of thorium, zirconium, and other metal-bearing sands.

Alert alkali producers, well aware of this broad trend, have pushed expansions so that adequate chlorine supplies appear assured for the next several years. During the first four months of this year there was an average daily production of 10,670 tons chlorine. By the end of next year the industry may have available an estimated additional 1,700-tons/day capacity. Among the more important projected expansions and recently completed ones are Diamond—planned 200 tons/day additional chlorine; Dow—400 tons; Wyandotte 300 tons; Jefferson—150 tons; Olin Mathieson—125 tons; Kaiser—100 tons; Solvay 100 tons; Weyerhauser 100 tons.

Through advances in technology, cell rooms are able now to deliver higher tonnages of product than for which they were originally designed. Increased chlorine production streams from two sources: (1) expansion of plant facilities, and (2) upping present production from inplace capacity by use of larger cells, higher amperages, and improved materials of fabrication.

Owing to the high cost of new chlorine facilities, there has been a general shift away from the erection of further new captive plants. Such capital is being advantageously used to enlarge primary product lines which ordinarily earn higher rates of return. This mounting cost has arisen not only because of a universally felt inflation, but is due, perhaps, in an even larger measure to embellishments resulting from the physical nature of this business. Increased emphasis is directed toward plant and community safety. Caution is exercised to avoid escape of even small amounts of chlorine in the air with its accompanying odor and fume problems. Discharge of effluent is discouraged so improved waste disposal systems must be installed. Employee comforts are stressed. Vigilant cleanliness in mercury-cell rooms reduces health problems to a minimum. Objectionable dust and fumes in caustic soda processing are exhausted. Although these costs disarmingly appear incidental, their summation is one of magnitude.

Chlorine, a charter member of the heavy chemical family with its classically established production methods and a finite technology, offers monetary satisfaction only to those firms satisfied with profit margins lower than those popularly associated with the chemical process industries. It is significant, perhaps, to note that chemical firms showing the highest rates of return on investment are not in the merchant chlorine business.

Acknowledgment

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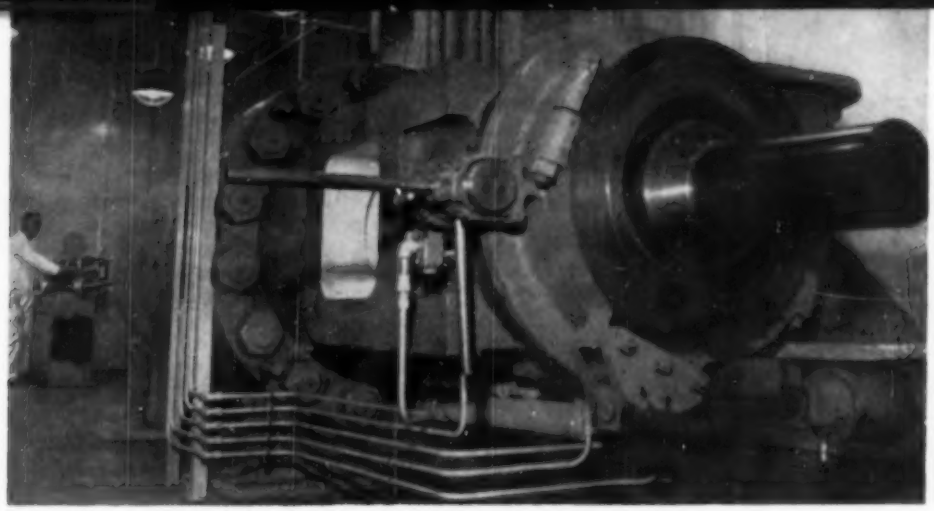

Fig. 5. Propellant extrusion press.

PROCESSING RUBBER-BASE COMPOSITE ROCKET PROPELLANT

The author examines one of the areas of the expanding rocket industry—composite propellants—where the educational background and engineering potential of the chemical engineer may profitably be applied.

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The glamour of the rocket industry offers a powerful appeal to technically trained people. Scientists and engineers are intrigued by imaginative and creative projects such as rocket-powered missiles, rocket-powered planes, earth satellites, and spaceships. Naturally the chemical engineer can be expected to seek his place in such an industry.

However, a cursory examination of the want ads of journals associated with the rocket industry may prove somewhat confusing to the chemical engineer unfamiliar with the language of the industry. He may wonder whether a chemical engineer can qualify to fill positions described functionally in such advertisements as: applications engineer, dynamics analyst, performance engineer, production expert, and systems analyst.

Actually, the chemical engineer has an educational background to satisfy many of the engineering requirements of the rocket industry. This article presents one of the areas where he can apply himself and become a part of the industry, this being the processing of propellant for the rocket-propulsion motor. Specifically, covered here are the processing aspects of the development of solid, extrudable, rubber-base composite propellants containing ammonium nitrate oxidizer. These propellants have a wide range of utilization including JATOs, booster rockets for missiles and sleds, stages for multistage missiles, gas generators, and many others.

Table 1 shows the composition of a typical propellant and the range of percentages of the individual components as they are generally used:

Table 1.—Propellant Composition

	Wt. %	
	Typical	Range
Synthetic rubber	10.0	5-15
Carbon black	2.0	0-5
Plasticizer	2.0	0-5
Curatives	0.4	0-1
Age resistor	0.3	0-1
Oxidizer	83.0	75-90
Burning-rate catalyst	2.3	0-4
	100.0	

The synthetic rubber serves as the major portion of the fuel and also serves as the matrix for holding the other ingredients together.

The carbon black reinforces, or strengthens, the polymer and acts as a part of the fuel system.

The plasticizer is a processing aid and serves too as part of the fuel.

Curatives impart the necessary physical properties to the polymer system. The age resistor protects the polymer from atmospheric oxidation and other aging effects.

The oxidizer provides the oxygen required by the fuel for combustion.

The burning-rate catalyst provides a coarse control of the burning rate of the propellant.

The combined synthetic rubber, carbon black, plasticizer, curatives, and age resistor are often referred to as the binder.

The processing of the propellant can be placed simply into these eight categories:

case and component preparation
restrictor and copolymer binder preparation
oxidizer preparation
mixing
blocking and extrusion
trimming and restricting
curing
final assembly.

These categories are illustrated in a simplified flow diagram form in Figure 1. Case and component preparation is included, since the processing of propellant is not considered complete until it has been loaded into the rocket case.

Fertilizer-grade ammonium nitrate prills are a cheap and convenient raw material source. However, the coating applied to the prills to improve their flow properties is generally omitted for propellant oxidizer use. Consequently, the oxidizer may be received with considerable agglomerates depending on the manufacturing operating conditions, method of packaging, and environmental conditions during transportation and storage. Caked oxidizer must be crushed to flowable prills before processing can proceed. This primary crushing operation is generally not difficult. Standard crushers such as the rotary crusher will readily reduce the agglomerates with little attrition.

Propellant raw materials which would contribute significant quantities of moisture to the propellant must be dried. Water in propellant adds weight and is detrimental to storage properties. Generally, the moisture content of the propellant is held below 0.3% and preferably below 0.1%. In order to maintain the low level of moisture, those stages of processing where the ammonium nitrate, the binder, or the propellant are exposed to the atmosphere, must be conducted under conditions of controlled temperature and humidity because of their hygroscopic nature. Humidity is controlled at approximately 30 grains abs. and temperature is controlled at approximately 85° F. Preferably, ammonium nitrate is maintained at a temperature exceeding 90° F. during processing as it undergoes a crystalline phase change at that temperature. However, in an atmosphere at 85° F. sufficient process heat is retained, providing the material moves rapidly through the process, to keep the temperature of the nitrate above 90° F. This effects a reasonable balance between process temperature requirements and operating personnel comfort.

Ammonium nitrate may be dried in conventional drying equipment such as the tray, rotary, or vacuum dryer. When available, steam is generally the preferred source of heat for economy and safety. Drying temperatures range from about 175 to 225° F. and drying cycles vary from about 1 to 12 hr. depending on the type of drying equipment and the initial moisture content of the oxidizer. At lower temperatures the drying cycle is unduly long and at higher temperatures the danger of decomposition is increased. Initial moisture content of the oxidizer varies from 0.1 to 0.3% and moisture content after drying varies from 0.02 to 0.05%. The oxidizer is dried before grinding to improve the flow properties for the grinding operation. When the drying operation is conducted in equipment such as a rotary dryer, special care must be taken to avoid undue attrition which would require an additional operation to screen out fines and irregular particles. These fines and irregular particles may cause serious bulk flow problems in the grinding operation.

After the oxidizer has been dried, it is ground to the particle size required to provide a propellant with the proper burning rate. Burning rate of the propellant increases with reduced nitrate particle size and decreases with increased particle size. Because of the effect on burning rate rigorous control of the grinding operation is required. The effect of particle size on physical properties of the propellant type discussed herein is almost negligible. Particle sizes required range generally from about 5 to 500μ. Conventional grinding equipment such as the hammermill is used for the grinding operation.

Operating problems are associated with the poor flow properties of the nitrate. If inadequately dried, the prills will bridge in the feed hopper and the feed screw cannot pick them up. As discussed previously, fines aggravate this problem since they fill the voids between the prills causing the oxidizer to pack. Pulsating panels have been used to break such bridges. Good hopper design can contribute to the prevention of the formation of the bridge. Hoppers with sides sloped at a minimum of 60° are used. Bridges which may form from all-ground oxidizer in later operations are much more difficult to break. The ammonium nitrate has a tendency to agglomerate on grinder parts and in pneumatic conveyor collectors. Shutdown for cleanout does not contribute to a well-lined-out operation. Control of particle size, using sieve analysis, has not proved satisfactory. The particles agglomerate and the sieve analysis is not accurate for fine grinds. A subsieve sizer is accurate for the fine particles but inaccurate for coarse grinds. Adequate process control has been developed by making microscopic analyses to determine particle size for specific hammer speeds and screen sizes. With such analyses over the range of operating conditions for the machine, particle size can be adjusted by setting the machine to operate at the conditions known to give the desired particle size.

Binder Preparation

Binder preparation includes drying of the rubber; breakdown of the rubber to reduce viscosity and improve plasticity; addition of carbon black; and incorporation of age resistor, plasticizer, curatives, and other special ingredients. Moisture content of the rubber as received may be as high as 1.0%. In order to maintain the desired moisture content of the propellant, the rubber is dried to about 0.1% moisture. Although other methods can be used, the drying operation is best conducted in a heavy-duty mixer of the type used in the rubber industry. Heat generated by the intensive action of the mixer blades in masticating the rubber readily drives off the moisture. The continuous exposure of fresh surfaces aids in releasing the moisture. Viscosity of the rubber may vary from about 20 to 50 Mooney. The viscosity range is reduced to about 20 to 30 by blending or working in the mixer. The lower viscosity aids the propellant mixing process. The carbon black content of the rubber may not be within the formulation specifications and is adjusted in the binder mixer by blending or addition.

Other ingredients may be added at this time or as a preliminary operation in the propellant mixing step. Curatives which are readily active at low temperatures would not be added prior to propellant mixing. Although the preparation of the rubber binder may be conducted in an undehumidified atmosphere, after it is dried the binder must be protected or moved to a dehumidified atmosphere to prevent moisture pickup. Figure 2 shows a binder preparation setup with a mixer on top which discharges into an extruder below. Material extruded is cut into sections for transfer to the next process step.

Mixing

Propellant mixing is the most critical step of the process. Adequate mixing demands the incorporation and dispersion of the oxidizer and burning-rate catalyst into the rubber binder, the rubber being the continuous phase. The propellant is then a rubber heavily loaded with salt. The ammonium nitrate is added in increments until incorporation is attained. Increment size is controlled to prevent the mix from falling apart. The number of increments may vary from two to as many as six in extreme cases. Generally, three increments are adequate. After incorporation, mixing is continued to break up oxidizer agglom-

erates and achieve adequate dispersion. Burning-rate control is accomplished not only through oxidizer particle size and quantity of burning-rate catalyst but through extension of mixing time. Over-all mixing time may vary from approximately 30 min. to as long as 2 hr. where high burning rates are desired.

Burning Rate

In some cases low burning-rate requirements do not permit sufficient mixing time to achieve good incorporation and dispersion. Batch-to-batch reproducibility then suffers. This shortcoming can be overcome by adding a burning-rate inhibitor so that additional work can be put into the mix to obtain adequate incorporation and dispersion without exceeding burning-rate specifications. The effect of mix time on burning rate and the effect of burning-rate inhibitor are shown in Figure 3. Care must be taken to control the temperature of the mix to prevent scorching, or incipient curing. Preferably the mix temperature is controlled at a maximum of 140° F. The degree of scorch has a time-temperature relationship, consequently extended mix time generally results in a stiffer, less plastic mix. Scorched propellant may cause poor consolidation, swelling, and distortion of the formed propellant from the extrusion process. Generally, a portion of the mixing step is conducted under vacuum to remove air bubbles from the mix. This may not be necessary if adequate evacuation is provided in the blocking and extrusion operations. Mixing is conducted in the rugged, heavy-duty-type mixers common to the rubber and plastic industries. They are equipped with a compression ram to hold the propellant in the mixer bowl where the dispersion blades can get a good bite. A vacuum cover is provided to permit evacuation of air from the mix. The mixer bowl is jacketed for circulation of cooling water. Sometimes the blades are cored for circulation of water where additional cooling surface is required. Mixer performance may vary even between supposedly identical mixers, requiring minor modifications to mixing procedures to achieve comparable mixes. This effect is attributed to slight differences in blade-to-bowl clearances, blade contour, and metal surface finish resulting in different mixing intensities. A typical propellant mixer is shown in Figure 4.

Extrusion

Mixed propellant is formed to the desired geometric configuration by extrusion with hydraulic extrusion

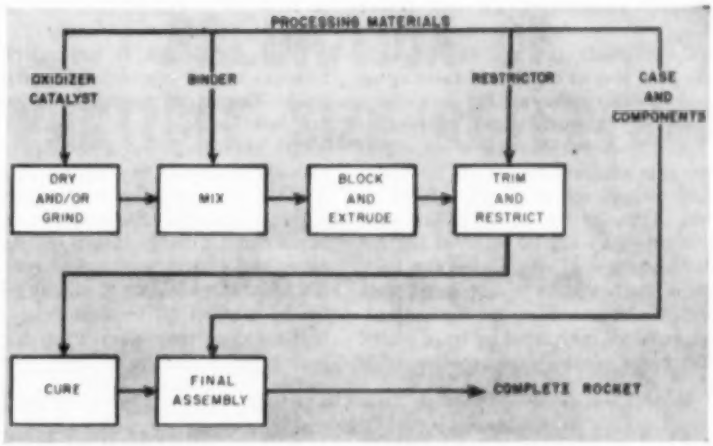


Fig. 1. Schematic flow diagram for CPN propellant.

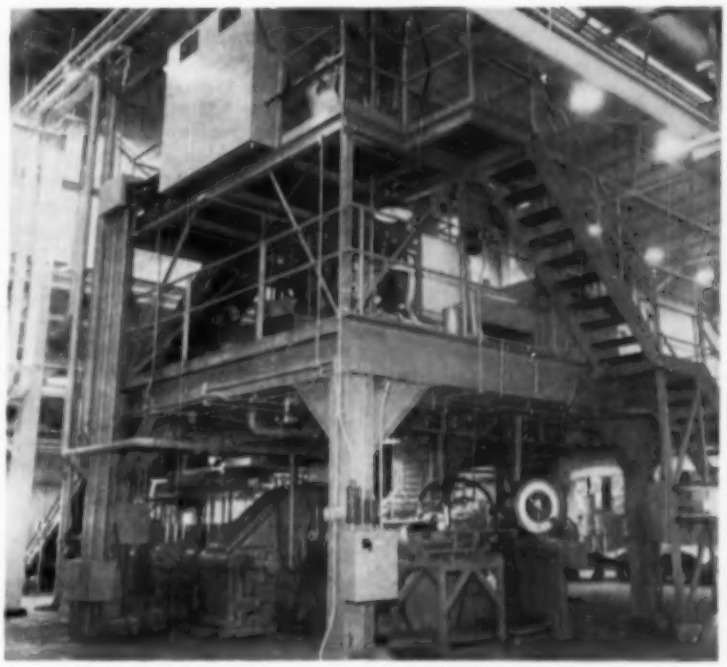


Fig. 2. Mixer and extruder for copolymer preparation.

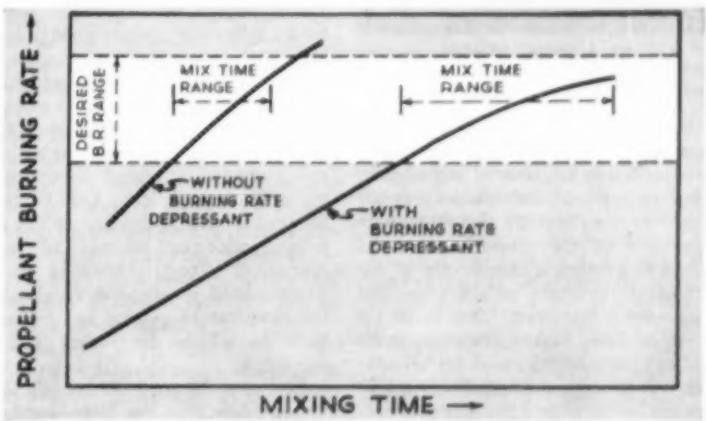


Fig. 3. Effect of mixing time on propellant burning rate with and without depressant.

presses. Preblocking the mix before charging the extruder is generally practiced with the use of hydraulic blocking presses capable of exerting up to 3,000 lb./sq. in. on the propellant. Evacuation of the basket of the press is required before exerting force. This prevents adiabatic heating of air which may cause an explosion. Blocking cycles run in the order of 10 min. Blocking may not be required but has the advantage of simplifying the loading of the basket of the extrusion press and also of permitting the higher loading required for extruding large pieces. Extrusion presses capable of exerting

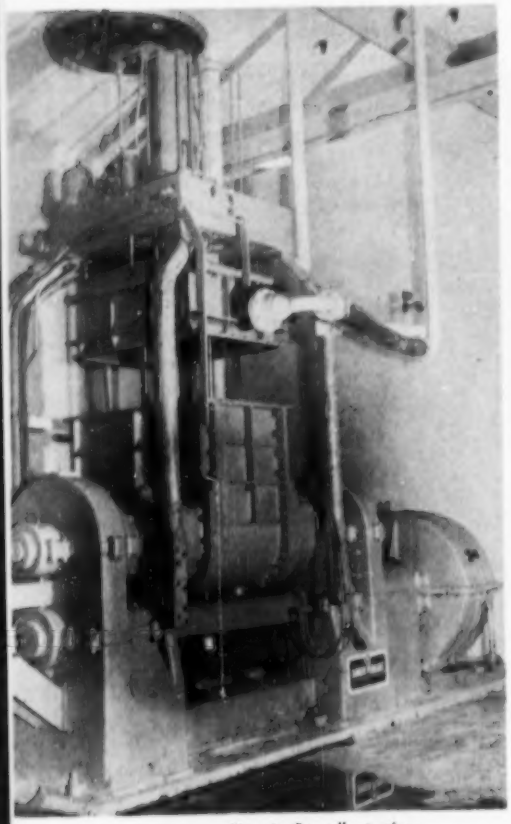


Fig. 4. Propellant mixer.

a force in excess of 2,000 tons have been used. After loading, the basket is evacuated to remove air before force is applied. Extrudability is affected by the hardness and flow characteristics of the propellant and the size and geometric complexity of the extrudate. Pressure on the propellant may vary from about 3,000 to 10,000 lb./sq.in. The basket can be jacketed and the die sections cored for circulation of cold or hot water. Cooling may be required to reduce the skin temperature of the propellant and heat may be required to improve the flow properties at the friction surfaces.

Good die design is imperative to achieve a well-consolidated extruded stock. Contoured approach section, a polished surface, and adequate land length are mandatory. The more complex the design of the formed propellant, the more complex becomes the die design problems. Even with careful balance of die design factors, extrusion rates, and extrusion temperatures, the die may require several modifications before it meets all requirements. Extrusion rates may vary from a few inches per minute to as high as fifty inches per minute. Extrusion cycles may vary from about 20 to 60 min. Figure 5 shows an extrusion press extruding a tube of rubber-base composite rocket propellant.

Trimming

The formed propellant is cut from the extruder by one of several types of cutters, generally a guillotine type. The propellant at this stage is commonly referred to as a grain. As the guillotine makes a rough cut a final trimming operation is required to meet dimensional specifications. Trimming may be done before or after curing. Where dimensional control is critical, trimming is preferably accomplished after curing because of dimensional changes that occur during cure. Extrusions will usually shorten slightly and the cross-section will get larger. Both the green and the cured propellant cut and machine readily. Cutting has been conducted with the band saw and with rotary cutters. Machining has been accomplished with a lathe and with special contouring machines.

The surfaces of the grain which are not burning surfaces during the rocket firing are inhibited from burning by application of restrictor. The restrictor being used with the rubber-base propellants discussed in this paper is similar to the propellant binder. The formulation includes a polymer reinforced with a furnace black, a plasticizer selected to impart good processing and superior low-temperature properties, age resistors to insure long life, and curing agents. It is prepared in the same type of equipment as is the binder and is sheeted on a three-roll calender. Sheeted restrictor is generally from 1/16 to 3/16 in. thick. Restrictor may be bonded to the propellant with or without adhesives. Normally, direct propellant to restrictor bond is adequate to withstand the temperature cycling and vibration tests to which the rocket will be subjected.

Severe problems, such as high velocity gas flow past the joined surfaces, require application techniques using adhesives. The restrictor may in some cases be subjected to high temperatures for relatively long durations which require that the restrictor be insulated to prevent breakdown. As the restrictor bonds to the rubber on the propellant surface, the more oxidizer particles exposed on the surface the less the opportunity for a good bond. The periphery will usually have less nitrate at the surface than the end of the grain. In addition to adhesives, the bond can be improved by pressure application of the restrictor. Special fixtures have been used in which the restricted grain can be placed, vacuum applied to remove entrapped air, and pressure applied to the restricted surface to make an excellent bond. In many cases the restricted surface must also be bonded to a metal support which is part of the internal hardware of the rocket. The rubber-base restrictor is adequate for this purpose.

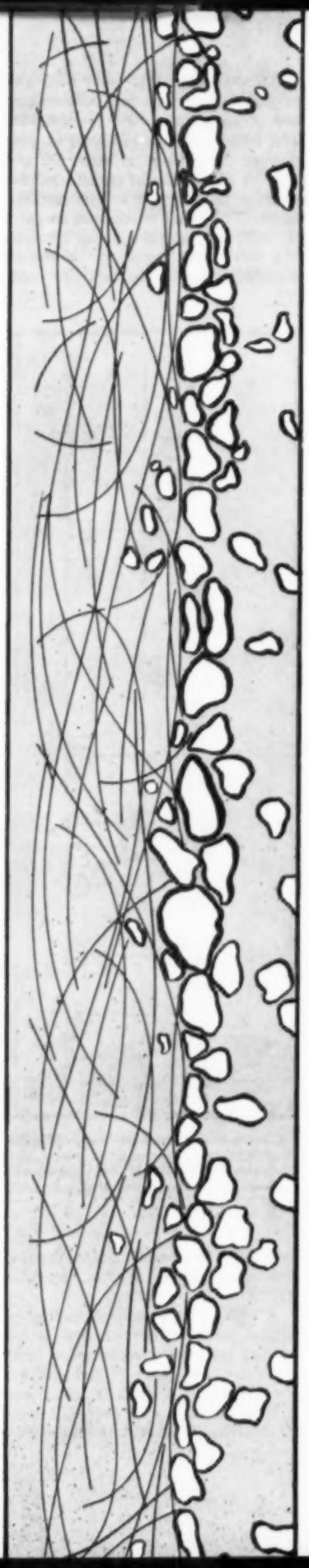
The grains are cured in an oven at an elevated temperature. The temperature at which the oven is operated and the time required to achieve curing depend on the cure system used in the propellant formulation and the physical characteristics desired. Temperatures utilized vary from 175 to 225° F. and curing times vary from 16 to 48 hr. Intricate grain shapes and grains made with soft propellant may require support to prevent slumping.

Final Assembly

Preparation of the rocket case and metal components includes degreasing, removal of strippable protective coatings, phosphatizing, painting, hydrostatic testing, application of insulation, and insertion of rupture disks. Final assembly includes insertion of the grain into the rocket case, placement of supporting hardware, attaching the head, insertion of the starter disk, and related operations. Special jigs and fixtures are used to insert the grain in the proper position without disfiguring the surfaces.

There are many aspects of processing propellant which are challenging to the chemical engineer, including process development, process evaluation, experimental design, process control, and safety. A discussion of all aspects is beyond the scope of this paper. The processing chemical engineer interested in associating himself with the rocket industry has an opportunity to apply both the theoretical and practical aspects of his chosen field to the solution of the problems encountered in the processing of rubber-base composite rocket propellant.

Presented at A.I.Ch.E. meeting, Baltimore, Maryland.



PREDICTION OF PARTICLE SIZE RETENTION

for papers, felts, and nonwoven fabrics

An attempt to develop a fast, commercially accurate method of determining micron retention of paper, felts, and nonwoven fabrics is described. Freely available and easily obtainable data have been investigated. This preliminary accomplishment will enable the reader to evaluate the method outlined.

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In recent years the conditions and characteristics of precoat filtration have been explored at some length, and the superior job performed in many cases has been rightfully acknowledged (*2*). Since in many cases use of a precoat is objectionable, an alternative to a precoat atop a relatively coarse filter medium is the use of a more highly retentive filter medium such as paper, felt, or nonwoven fabric.

Regardless of the reason for choosing a paper, felt, or nonwoven fabric, as the most suitable one for the job at hand, two basic types of information concerning the filter medium are needed: (1) chemical and temperature resistance of the material, and (2) size of the particle that will be retained by the medium on a single pass.

The first requisite information namely, chemical and temperature resistance, is normally available from the manufacturer.

Data on micron retention is at best only partially available. Reasons for this dearth of available data on micron retentions are twofold. First the major use of papers, felts, and nonwoven fabrics is usually not filtration, and, for this reason the manufacturers have developed data which are not specifically aimed at filtration. Second the present method of determining micron retention, although extremely accurate, requires equipment which itself is not commonly available, and the use of which is time consuming.

J. F. Zievers serves as director of Research & Development, R. W. Crain is director of Laboratory Test Work, and W. L. Werchun is research physicist.

Development of Method

1. Air permeability data are obtainable from most manufacturers of felts or nonwoven fabrics. Such data are developed as a matter of course and are usually included as a part of the manufacturers' specifications on such materials.

2. Micron retention data are available from some technical papers for ready reference, with additional data obtainable only with considerable time and highly specialized equipment, such as the photomicroscope employed by Wrotnowski (*4*).

3. Liquid permeability falls into the category of readily obtainable data and a number of methods can be used. The following is the method adopted because of its simplicity.

A glass column 1¾ in. I.D. and 24.5 in. long is mounted in a vertical position. The bottom of the column is fitted with an orifice so constructed that a disk of nonwoven fabric to be tested can fit into it and can be arranged so that flow through it can be simply stopped (Figure 1). The sample to be tested is placed on the disk, the column is filled with distilled water to a height of 24 in. The time allotted for it to run from that height to a height of 12 in. is recorded by stop watch. This method is referred to as the hydrostatic head flow test (H.H.F.T.). Since the H.H.F.T. is recorded in seconds, a low value indicates a highly permeable material and vice versa.

4. Another type of data which is readily found is residual turbidity after filtering a raw-sugar solution. This test is performed as follows: 1½ l. of the standard raw-sugar solution is in-

CALCULATIONS OF PER CENT VOIDS

(A) Calculations of per cent voids for bonded fabrics:

$$E = 1 - \frac{G}{32.7T}\,\frac{(1-B)+B}{d_f d_b}$$

where:

E = void fraction
G = gauge of fabric
T = thickness in mils
B = binder fraction in fabric
d_f = density of fibers
d_b = density of binder

(B) Calculation of per cent voids (Universal):

1. oz./sq.yd. $= 45.8\,\frac{(\text{wt., g.})}{\text{area squared}}$ Convert result to lb./sq.yd.

2. Density (% sp.gr.) $= \frac{\text{lb./sq.yd.} \times 2.136}{\text{thickness (in.)}}$

3. Per cent voids $= \frac{100 - \text{density (\% sp.gr.)}}{\text{fiber density}}$

(C) Fiber densities (for bonded, woven, pressed fabrics)

1. Cotton	1.54	6. Dynel	1.30	1. Viscose	1.5
2. Rayon	1.52	7. Orlon	1.16	2. Hycar	1.0
3. Dacron	1.40	8. Nylon	1.14	3. Geon	1.13
4. Acetate	1.32	9. Polyethylene	0.92	4. Cellulose	1.58
5. Vinyon	1.30	10. Arnel	1.30		

Binder densities

Table 1.

Test No.	H.H.F.T.	Actual air permeability (Frazier test methods)	Graphically predicted air perm.
P-113	29	50	50
P-20	17	70	85
P-15	8	185	181
P-7	7	210	208

Description of media used in laboratory tests: P-114—homogeneous wool felt; P-113—homogeneous wool felt; P-112—homogeneous wool felt; P-32—heavy pulpy paper; P-20—cotton, resin bound nonwoven fabric; P-15—cotton, resin bound nonwoven fabric; P-7—rayon, resin bound nonwoven fabric; P-5—rayon, resin bound nonwoven fabric; P-4—rayon, resin bound nonwoven fabric.

Table 2.

Test No.	H.H.F.T.	Microscope method (microns retained)	Estimated results (microns retained)
P-4	4	99	110
P-5	5	97	88.5
P-112	10	30	44
P-10	13	54	34
P-20	17	34	26
P-32	45	10	9.8

(See note to Table 1; see also Figure 3.)

Table 3.

Test No.	Actual retention	Dow Chemical Co. dispersions used	Retention
P-32	10	6.4- 12.8 μ	approx. 30%
		14.4- 28.8	complete
P-114	30	14.4- 28	none
		28 - 56	approx. 90%
		56 -105	complete
P-20	34	14.4- 28	none
		28 - 56	approx. 10%
P-10	54	14.4- 28.8	none
		28 - 56	approx. 10%
		56 -105	complete
P-4	99	56 -105	approx. 10%

(See note to Table 1.)

troduced into the laboratory filter and subjected to the standard temperature and pressure prescribed for the test. The solution is allowed then to pass through the medium in each case and samples of the effluent are checked for residual turbidity on a spectrophotometer. The result is recorded in parts per million. Since the clarity obtained is a function of the micron retention, the comparison of the turbidity readings is an invaluable aid in the predetermination of micron retention (*1, 3*).

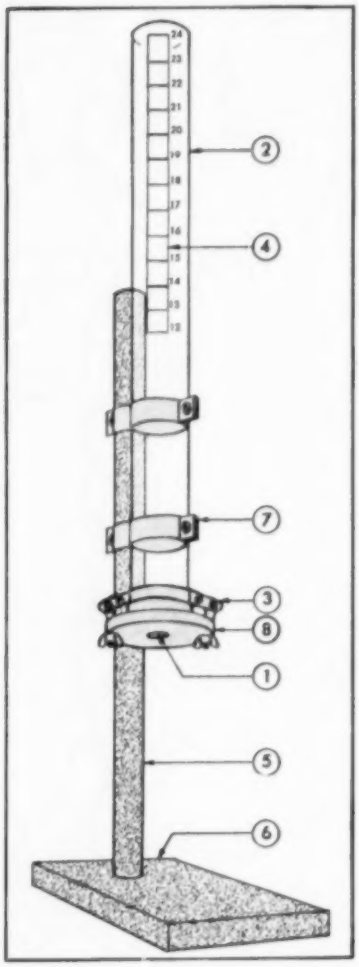


Fig. 1. Hydrostatic head flow tester: 1) orifice; 2) glass column; 3) orifice plate retainer quick disconnect; 4) graduations; 5) support rod; 6) base; 7) column holding clamp; 8) orifice plate.

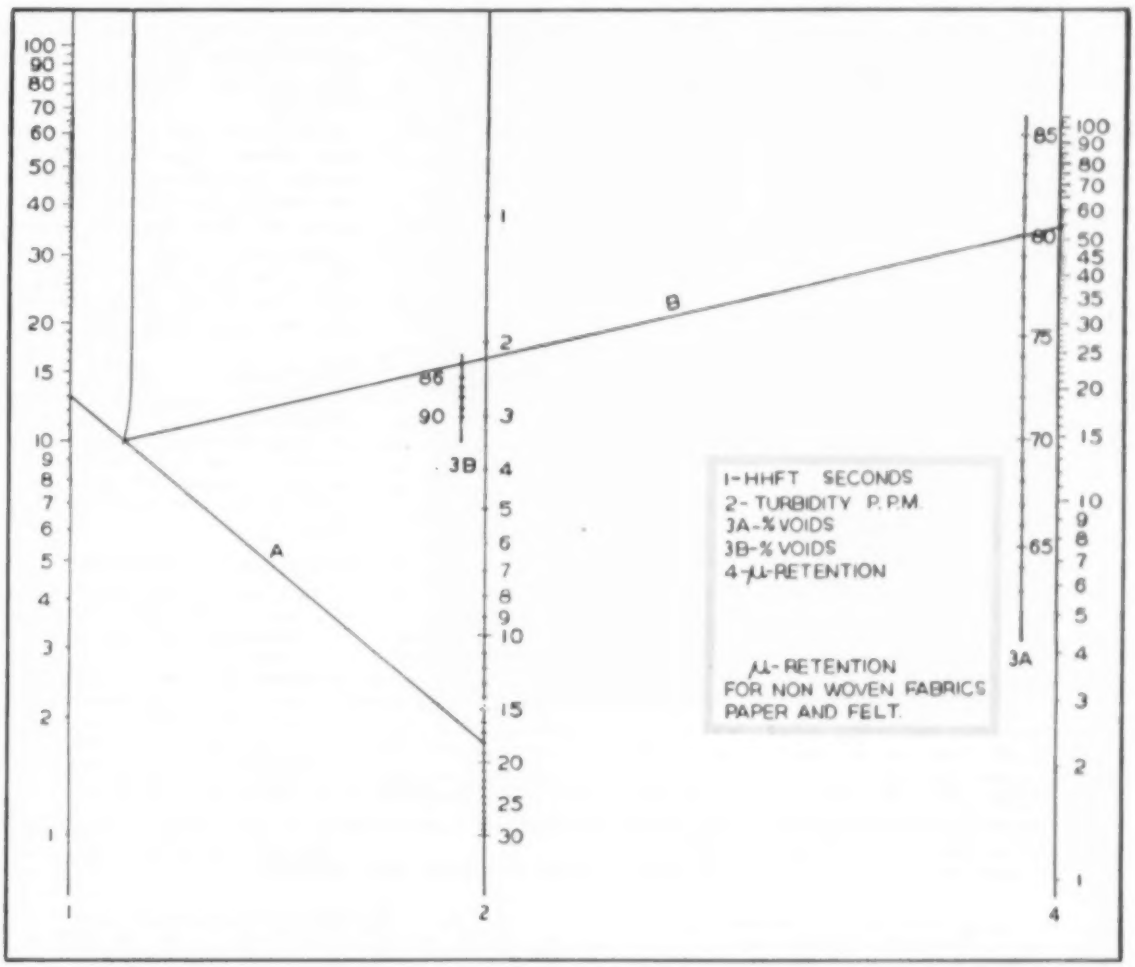
A high parts-per-million reading indicates poor micron retention; a low reading indicates good retention. Since a relative comparison of turbidity was the end result desired, it was necessary to standardize on degrees (Brix) of solution, pressure, and temperature

at which each test was run as follows: Purity 99.8, *T.* 60° C., *P.* 3 lb./sq.in. gauge, 10° Brix.

5. Certain data, available from the Dow Chemical Company of Midland, Michigan, are in the form of polystyrene latex dispersions on which the average micron size has been determined (and also given is the standard deviation on the frequency distribution). Use of these dispersions is described (see p. 496 and Table 3).

6. Most manufacturers supply information on porosity (or per cent voids) of the various media. Such data can be calculated. Depending upon the material in question, an investigator can make one of the formulas, as shown in calculation (p. 494), apply.

Once the available and/or obtainable data are recognized, the problem is reduced to one of efficiency in the employment of the data. The first step, correlating air permeability and liquid permeability or H.H.F.T., is carried out so that at a later date whichever data are available can be put to use. The correlation was necessary also because a goodly number of the laboratory determinations of micron reten-



HOW TO USE PARTICLE RETENTION NOMOGRAPH

(Fig. 4)

STEP I

Draw a line (A) from the H.H.F.T. value on scale 1 to the turbidity value for that fabric on scale 2.

STEP II

In so doing, line (A) has intersected the neutral or guiding line located between scales 1 and 2. From this point of intersection on the neutral line, a line (B) is drawn through the per cent voids scale at the point which has been calculated for that fabric. The per cent void scale has been divided into two scales; namely, 3A which includes 63 to 85%, and 3B which takes in 86 to 90% voids.

STEP III

When line (B) is extended, it will pass through scale 4. The value indicated on scale 4 by the intersection of line (B) is the micron retention for that fabric.

Table 4.—Comparison of Predictions by Short Method and by Nomograph

Test No.	Microscopic determination of micron retention	Short method micron retention	Determination of micron retention from nomograph
P-32	10	9.8	10
P-112	30	44	30
P-20	34	26	28
P-10	54	34	54
P-5	97	88.5	83
P-4	99	110	105

(See note to Table 1.)

tion are reported in conjunction with air permeability. Accordingly, samples of all materials on which air permeability data were available were tested to determine H.H.F.T. Results were plotted and were seen to fall on equilateral hyperbolic curves, the equation of which is $XY = 1444$ (see Figure 2). After the curve was plotted, additional data on air permeability were used to predict H.H.F.T. results. These predictions, set against actual laboratory tests, were found to compare satisfactorily. Some typical values are given in Table 1.

The next step was to plot permeability against micron retention from the laboratory data available since, if a good correlation could be found, this would be the shortest possible solution to the problem. The curve drawn through the resulting points fitted Equation $XY = 441$ and all points fell almost exactly on the curve (Figure 3). The next step was to find *actual* laboratory data from outside sources to check against *estimates* of micron retention made as a result of tests on a material that was common to both determinations. Once again the predictions accorded favorably with the actual laboratory determinations. Some results are indicated in Table 2.

As a further step, samples of other materials—papers, felts, and nonwoven fabrics—were tested to determine the H.H.F.T. The curve (Figure 3) was entered to predict micron retention, and the estimates were checked with the polystyrene latex dispersions available from the Dow Chemical Company. Once again the results were most favorable. Some of them are listed in Table 3.

Up to this point, four of the six basic types of data available have been used. Also it may be stated that the method described here is simple and fast and is accurate to within a few per cent in most cases. Referred to as the *Short Method*, it contains some inaccuracies, even erratic results, especially in the testing of isotropic as opposed to oriented nonwoven fabrics. Because of such inaccuracy, it should be noted that the method, as it is developed to this point, is applicable only where there is an even distribution of fibers since isotropic nonwoven fabrics have a much less even distribution than do the oriented types. With isotropic nonwoven fabrics (these appear sort of splotchy when held to the light) tests produce an H.H.F.T. for an average of the dense areas and the less dense areas which would indicate rather good micron retention, but the micron retention of a fabric is only as good as the largest pore size, and because of the nature of the H.H.F.T. one large pore can give the same reading as many small pores. It can easily be observed however that the micron retention would not be the same in both cases. The same conditions have been found to exist on tests made with woven fabrics. Therefore, to expand the applicability of the technique, a few simple corrections had to be added.

To correct for the case where one large pore might give the same H.H.F.T. result as a number of smaller pores, data have been employed on residual turbidity from a raw-sugar clarity test. Although two fabrics may give the same permeability on an H.H.F.T., the fabric with the larger pores will show a higher residual turbidity. To correct for the case where a *few* small pores will indicate a lower permeability (and hence a better micron retention) than a similar fabric containing *many* pores of the same size as those in the first-mentioned fabric, the data which are available on porosity have been used. (See Calculations of Per Cent Voids on page *494*.)

Thus, the six types of data have now been utilized. The interrelationship between these data and predicted micron retention have been plotted on the nomograph which appears as Figure 4.

Table 4 is a comparison of predictions by the short method (see Figure 3 and Table 2) and by the nomograph with laboratory determinations.

Acknowledgment

Gratitude is expressed for the willing assistance received from The Dow Chemical Company, Chicopee Manufacturing Corporation, and The American Felt Company. Without their aid the work on this project would have been difficult indeed.

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Presented at A.I.Ch.E. meeting, Seattle, Washington.

Fig. 2. H.H.F.T. (liquid permeability)—air permeability correlation curve.

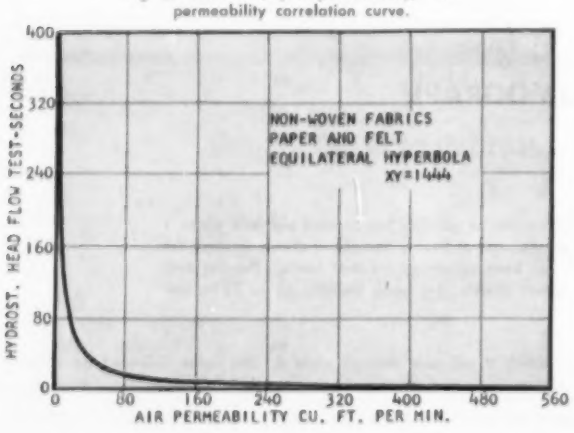
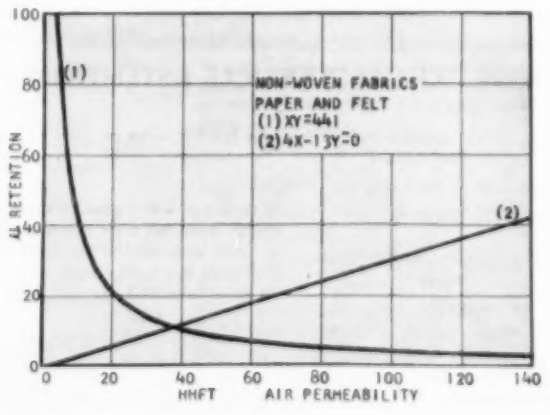
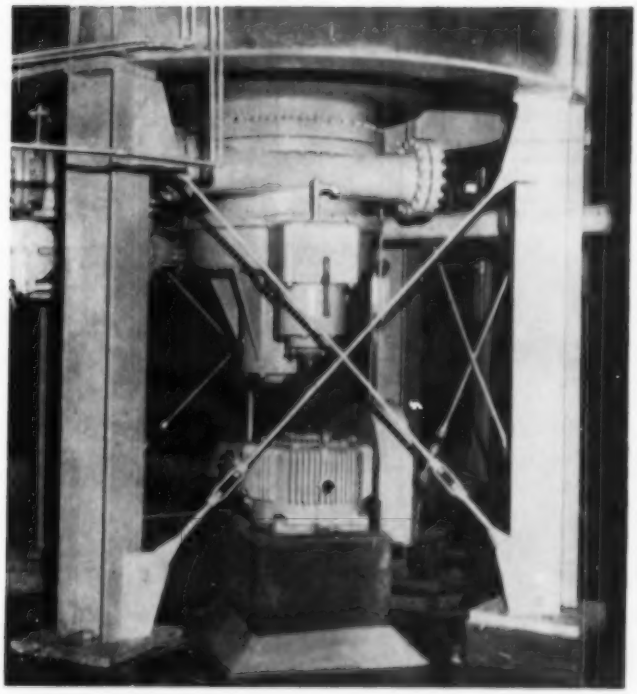


Fig. 3. *Short Method* micron determination curve.



CONTINUOUS PULPING OF WOOD CHIPS



Outlet device in bottom of digester.

One of the last major strongholds of batch processing in the chemical industry—wood-pulping technology—is under heavy attack by advocates of continuous methods. Here are some of the pros and cons plus a forecast for the future.

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The chemical industry as a whole has accepted one of chemical engineering's basic hypotheses: *for maximum product uniformity and operational economy, a process should be carried out on a continuous basis.* The exceptions which come to mind are mainly in operations like the pharmaceutical field where small batches of a wide variety of products are produced, frequently on a seasonal basis.

The wood pulp industry remains one of the few major industries which has resisted this movement in performing its primary operation—that of reducing wood to a crude cellulose fiber, although in the majority of mills all subsequent operations are now carried out on a continuous basis.

Advantages of Batch Digesters

There are a number of reasons for the reluctance to convert this particular operation from batch to continuous:

- **The chemical reactions within the primary reaction vessel, or digester, as it is commonly called, are extremely complex, and the mechanism of what takes place is not fully known. In fact, the chemistry of the operation is a subject of continued research and discussion.**

- **Not only are the reacting chemicals extremely corrosive, but so are the products of**

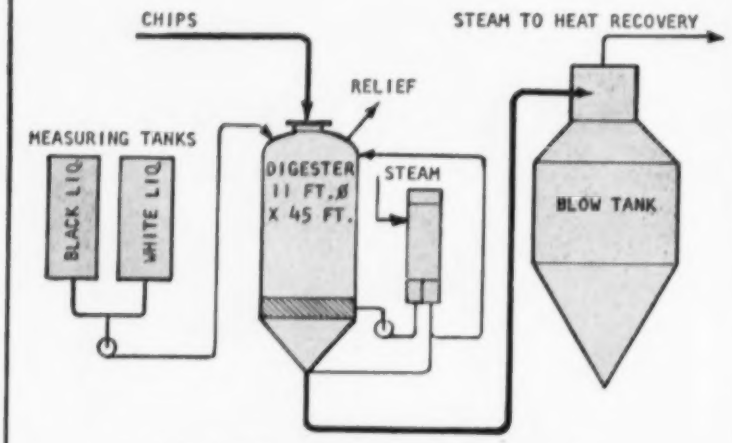


Fig. 1. Batch type digester for sulfate pulp.

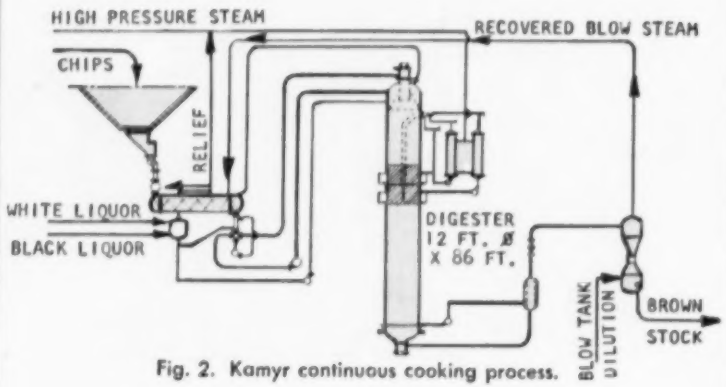


Fig. 2. Kamyr continuous cooking process.

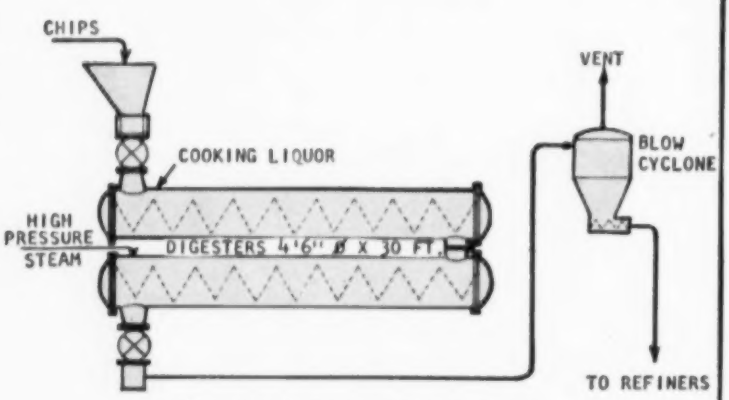


Fig. 3. Tube type continuous digesters.

reaction. The severity of attack varies considerably with wood specie. Even within the specie, variations are found from location to location and season to season. This problem alone has caused a great number of mills to hesitate to put all of their eggs in the continuous basket. With batch equipment, only a small proportion of the productive capacity will normally need repair or replacement at any one time.

- All of the mills have made great technical strides in producing a uniform high quality product. In addition, as a mill becomes larger, the approach to continuous operation becomes closer insofar as the most obvious benefits are concerned—uniform steam and power demands, and reduced man-hours per ton.

These considerations reduce the desirability of new apparatus, particularly in operating mills where much equipment in relatively good condition would become obsolete. In other words, the problem is not simply one of replacing worn-out digesters, but also involves chemical and heat recovery systems.

Problems of Batch Operation

On the other hand, for new installations, substitution of continuous digesters and suitable recovery systems for heat and chemicals should result in reduced capital cost and a reduction in operating cost for the entire mill.

The problems still faced by the users of batch pulping equipment are:

- Cyclic steam and power loads as each vessel is heated to reaction temperature.
- Large amount of nonproductive or wasteful digester volume due to shrinkage of the raw material during reaction and the time required for emptying and filling of the vessel.
- Heat losses incurred by intermittent heating and cooling of the digester.
- Low temperature level of the reclaimed heat as usable hot water (approximately 170° F. maximum, often lower). Most mills find there is a surplus of available low level heat from their digester operations which they are forced to recover because of attendant air pollution considerations and then dispose of, while they must at the same time raise the temperature of the other process streams by steam.
- Corrosion directly attributable to the intermittent operation of the digesters.
- Control problem of uniformly raising the temperature of all portions of the digester contents at the rates specified as optimum by the technical department. This aspect is becoming more serious as larger digesters are employed in an attempt to reduce the labor cost per ton of product.

Current Method of Producing Chemical Pulp

There are three main pulping methods now employed by the manufacturers of chemical wood cellulose pulps. These are called the sulfite, sulfate,

and neutral sulfite processes, and are differentiated by the chemicals used for delignifying the woody raw material.

The sulfite process involves the use of calcium, ammonium, magnesium, or sodium bisulfite salts of sulfurous acid in a sulfurous acid solution.

The sulfate process utilizes a mixture of sodium hydroxide and sodium sulfide in varying proportions. A batch-type digester for sulfate pulp is shown in **Figure 1.**

The neutral sulfite process uses a mixture of sodium sulfite and sodium carbonate, the proportions of which are adjusted so that the *p*H of the solution is on the alkaline side.

Digester Operation

The digester operation in all of the above processes is essentially the same. The vessels are filled with wood chips and delignifying solution; raised in temperature and pressure to about 100 lb./sq. in. gauge with sufficient venting to remove air, carbon dioxide, turpentine, and other volatile components; and then the entire digester contents are discharged to an atmospheric storage tank from which the raw cellulose fibers are withdrawn for further processing. Commonly, this discharge is effected by the steam pressure in the digester, and takes about 10 to 15 minutes. The enormous quantity of heat released during this short period requires a large recovery system if heat is to be reclaimed. Further, this vapor contains a large quantity of odorous compounds which are a nuisance to the surrounding community, frequently to the extent of a lawsuit.

The digester operation of the sulfite process is further differentiated from the other two in that sulfurous acid is extremely unstable with respect to temperature. The SO_2 gas must be vented back to a suitable recovery system for economical operation. Sulfurous acid is extremely corrosive and tile-lined digesters with type 316 stainless steel piping are used almost exclusively. Some success has been reported with the use of stainless-lined digesters, but it is significant that there are only 8 or 9 of these out of several hundred tile-lined digesters in operation. Stainless clad steels are seldom used.

The sulfate process is the least demanding insofar as special materials are concerned. Carbon steel is the common material, but 18-8 stainless steels are required for pumps and valves. It is not uncommon for mild steel digesters to lose as much as 1/16 of an inch annually in thickness, but stainless clad and lined digesters have not proven to be much superior. Inconel clad plate shows some promise, but the initial cost of such a vessel has prohibited its use except on an experimental basis.

For neutral sulfite, 316 stainless clad digesters and stainless piping are the general rule although, as the name indicates, the sodium sulfite sodium-carbonate buffer is adjusted to keep the digester contents at a *p*H of approximately 7 during the entire cooking period to protect the equipment from the extreme corrosive influences of the sulfite process. This method of producing wood cellulose is comparatively new and is used mainly for pulping hardwoods as contrasted with other systems described. Consequently, there is not the background of information available and there is considerable divergence of opinion with regard to materials, equipment, and method of digesting.

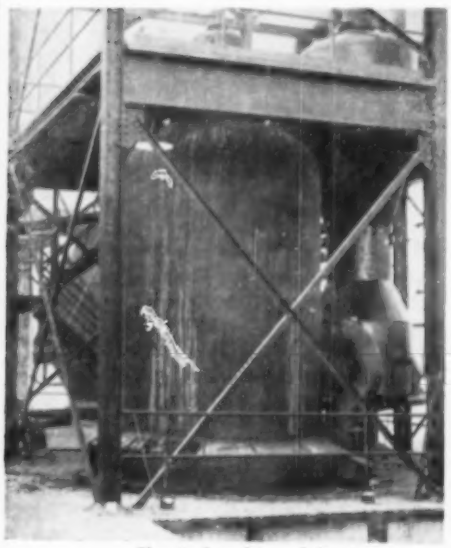
chemical engineering in PULP AND PAPER TECHNOLOGY

Requirements for Chemical Pulping

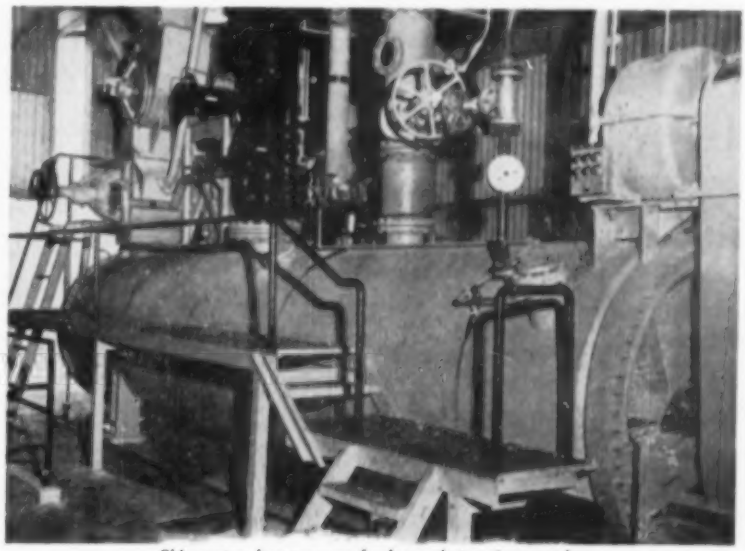
The consensus is that for best results in all three processes the following conditions must be met:

- **Complete submergence in the deliquefying liquor.**
- **Gradual rise in temperature to that required for reaction to allow time for diffusion of the reacting chemicals into the wood and for obstructing materials (chiefly air and other volatiles) to diffuse out.**
- **A period at reaction temperature for delignification.**

Generally speaking, the sulfite process requires the longest cooking time—3½ to 4½ hours for heating and 2 to 4 hours for reaction—and sulfate the shortest, 1½ to 2½ hours for heating and 1 to 2 hours for reaction. Neutral sulfite cooking times are generally in-between.



Blow tank and top of digester.

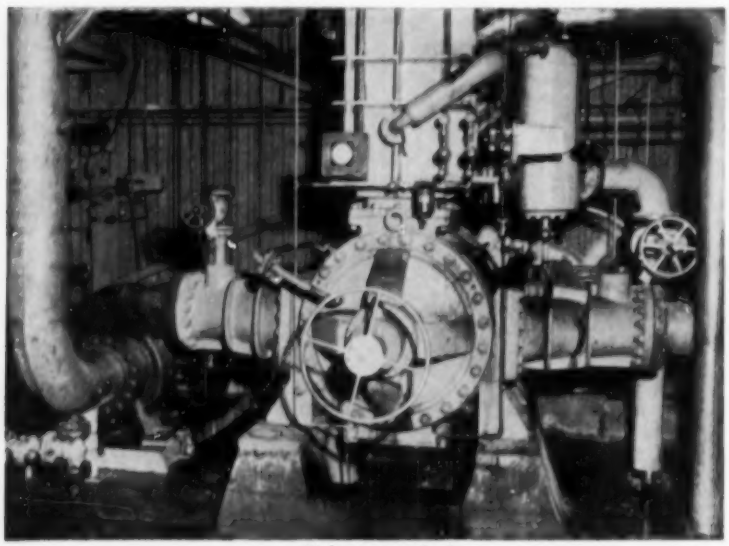


Chip meter, low pressure feeder and steaming vessel.

Present Status of Continuous Equipment

Of the continuous pulping equipment of proven ability now available, only the Kamyr system has attempted to duplicate, on a continuous basis, the foregoing requirements (Figure 2).

The continuous digesters of American Defibrator, Pandia, and Bauer-Greenco are based on a completely different principle, as they operate, fundamentally, in the vapor phase. The wood particles are either presoaked in the cooking liquor or are introduced dry through a screw press or star-type-rotary valve into the digester, with the cooking liquor sprayed over them. These digesters are horizontal, tubular units with internal conveying screws. Several units may be connected in series to give the desired reaction time. Usual time is 30 to 60 minutes under 100 to 180 lb./sq. in. gauge steam pressure.



High pressure feeder.

It will be noted that these times are considerably shorter than is normally required with batch digesters. It is also apparent that it would be extremely difficult to obtain perfect mixing of a heterogeneous mixture such as wood chips and cooking liquor in this type of vessel. (The standard wood chip is between ⅝ and ¾ in. square by ⅛ in. thick.) The abrupt temperature rise in these vessels also indicates a large thermal gradient through the wood particles. For these reasons this type of digester has been used almost exclusively for what is termed "semichemical pulps." These pulps are produced either by the sulfate or neutral sulfite process and consist of a chemical softening of the cellulose fibers and intercellular lignin coupled with mechanical separation of the fibers. This type of wood pulp finds wide application in the paper board industry where the added stiffness of the partially delignified fiber is particularly desirable. In addition to this, these digesters are being used extensively for sawdust and hammermilled wood waste unsuitable for producing standard chips. It appears that this type of particle, with its large surface area per unit weight, can be readily cooked to a uniform fiber. These fibers seem to be quite small compared to normal chemical pulp, and they are used mainly as a filler by the paper makers to extend their supply of chemical pulps and to obtain a smoother surface on their paper.

The tubular digesters have a great advantage over batch digesters and the Kamyr digester on this type of raw material. As has been mentioned, these units operate in the vapor phase and thus do not depend on liquor circulation for heat and chemical distribution. Sawdust, particularly, has a tendency to plug strainers, and in a digester offers a great deal of resistance to liquor circulation (see Figure 3).

The Kamyr continuous digester is a vertical vessel, fairly high for its diameter. The chips and cooking liquor are introduced at the top and settle by gravity to the discharge device at the bottom. The digester is unusual in that it is maintained under hydrostatic pressure to eliminate any vapor space in the top. This hydrostatic pressure, plus the downward movement of the wood and liquor, helps to minimize the effect of natural convection to heat the upper portion of the digester. The heating zone is located around the center of the vertical length of the vessel. Wood and liquor passing this zone are brought up to reaction temperature. Circulation is from a central pipe to a peripheral strainer section. By proper design it is possible to obtain any retention time desired in each zone for a given tonnage output. The pulp produced by this equipment appears to be equal to that produced in batch digesters with the same cooking cycle. As yet these digesters have found industrial application only for neutral sulfite and sulfate operation. The sulfite process still presents many difficulties because of the vapor pressure of sulfur dioxide. The problem is mainly that of introducing the wood chips without losing the reacting chemicals.

With regard to corrosion in these vessels, the absence of a vapor space and the elimination of thermal shock have markedly reduced the corrosion which is a problem in batch vessels. Some noncondensables do collect in the upper portion of the digester, as has been evidenced by corrosion of the digester filling lines and top cover where these portions have been made in mild steel. Replacement with 18-8 stainless steel seems to have eliminated these troubles.

The horizontal vapor phase digesters are normally constructed of 18-8 stainless, since these units are exposed to very corrosive conditions.

Cost

The installed cost of a conventional batch-digester installation amounts to only about 2 per cent of the total cost of a modern bleached wood pulp mill. Economies in this area, therefore, cannot do much toward reducing the capital investment required. Generally speaking, the digester building and equipment for a daily output of 300 tons of sulfate fiber per day would cost about $1,000,000 for a Kamyr digester compared to $1,500,000 for batch equipment. It is not possible to compare the tubular units as their product is not comparable, but the cost would be about the same or higher for equivalent capacity.

Future Possibilities

It appears that no great saving can be effected in the high cost of building today's wood pulp mills while present practices are followed. The future of the industry probably lies in new methods of pulping and less involved chemical recovery systems. Today's continuous digesters represent unique methods of handling a difficult raw material, and with modifications to meet industry's changing requirements, will probably appear as a part of pulp mills of the future.

Presented at A.I.Ch.E. meeting, Seattle, Washington.

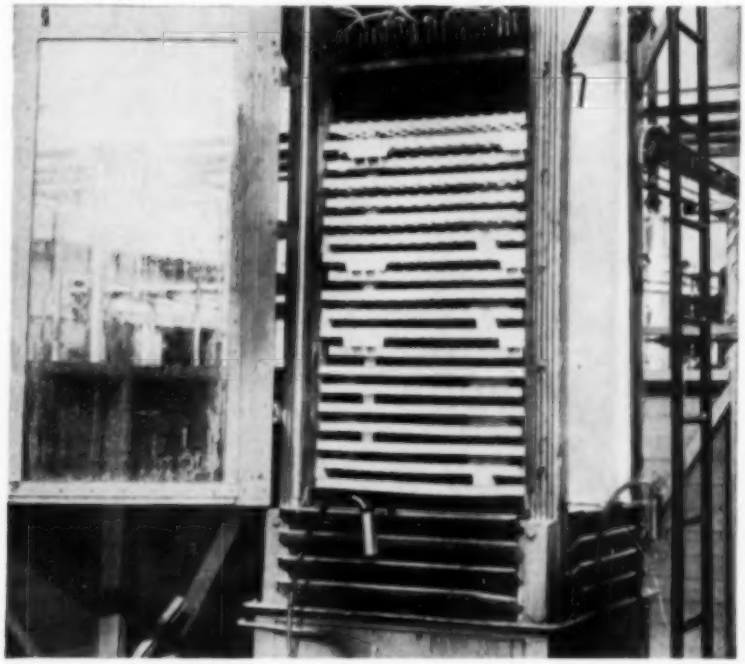


Fig. 3. Experimental test unit showing method of installing new plastic packing and distributor unit.

A NEW PLASTIC PACKING FOR COOLING TOWERS

A new plastic tower packing, developed for use in water cooling towers, is claimed to be well suited as a gas or vapor-liquid contact medium in other applications because of high mass-transfer coefficient, low pressure-drop characteristics, and relatively inert chemical structure.

A. L. Fuller, A. L. Kohl, and E. Butcher

The Fluor Corporation, Ltd., Los Angeles, California

The development of an improved packing for the contacting of large volumes of low-pressure gas with liquid, as required in water-cooling towers, involves the evaluation of numerous factors, including some which cannot readily be assigned a dollar value. Characteristics generally desirable for an ideal packing include:

1. high coefficient of heat and mass transfer
2. low pressure drop
3. low cost
4. open construction to minimize fouling
5. ease of installation
6. lightweight
7. deterioration resistance
8. freedom from channelling of either gas or liquid
9. adequate strength

It will be observed that the above-listed factors are interrelated. For example, a relatively high pressure drop (per foot of packing) can be tolerated if the packing has so high an efficiency that only a few feet of packed height are required. Such packing would undoubtedly be more expensive per unit volume than its low-efficiency, low-pressure-drop counterpart. However, the cost differential may be partially cancelled by the smaller volume required. Even if the total cost of the high-efficiency packing is higher than that of the low-efficiency materials, the economics for its use may be favorable because of the savings in sidewall costs and in liquid pumping head which can be realized when a lower tower is used. From such considerations, it is clear that the optimum packing can be selected only on the basis of an economic evaluation which includes the entire tower, and its operating costs. A further requirement is the necessity of selecting the optimum gas and liquid rates for each packing before a fair comparison of its merits with those of other packings can be made.

The present development is one result of many years of research on air-water contact during which time numerous packings were tested experimentally and evaluated economically. To expedite the tedious data processing and facilitate the evaluation, techniques have been developed to utilize high-speed electronic digital-computer procedures. A description of one of these techniques, the calculation of cooling-tower-performance coefficients, has been described in a previous paper (*2*).

Background

Packings used for cooling towers of the counterflow design may generally be classified as either splash or film type. Examples of several such packings are shown in Figure 1. The splash-type packing, which is the one most commonly employed in present-day towers, consists of grid decks which are generally spaced from 1 to 2 ft. in the vertical direction. The decks serve to break up the water which falls freely through the tower so that the mechanism of contact is similar to that of a spray column. The principal advantages of this type of packing are its economy, low pressure drop, and ruggedness. Because most of the air-water contact surface is provided by the free falling drops, rather than by packing surface, the quantity of lumber (or other material) required is relatively small and the grid members can be made thick enough to withstand deterioration without resulting in an excessively expensive tower. A schematic diagram of a successfully used redwood splash deck is included in Figure 1. As can be seen, the thinnest dimension of lumber used is 1 in. This particular packing has a record of more than 10 years continuous industrial service without showing signs of deterioration. It is generally used with a spacing between decks of about 2 ft. Some improvement in performance can, of course, be realized by using the same amount of lumber cut into a larger number of thin splash grids. However, this affects primarily the transfer occurring on the packing surface and since this represents only a small fraction of the total, the net improvement may not be great enough to justify the decreased strength and reduced life of the packing.

Film packing is defined as that type in which the water flows in a relatively continuous film on the wetted surfaces so that the surface available for heat and mass transfer is closely related to the surface area of the packing material. Film packings most commonly used for cooling-tower applications have been of the egg-crate type. These are constructed of wood slats with alternate layers crossed so that when viewed from the top, numerous square openings are seen as in an egg crate. A packing of this type is shown in Figure 1. A considerable portion of the research program was devoted to the development of the optimum dimensions and orientation for wood egg-crate packings. Data showed these packings to be highly efficient and potentially competitive with the more conventional-type packings, particularly when compared on an annual cost basis.

Fig. 2a. Extruded hexagonal tube packing.

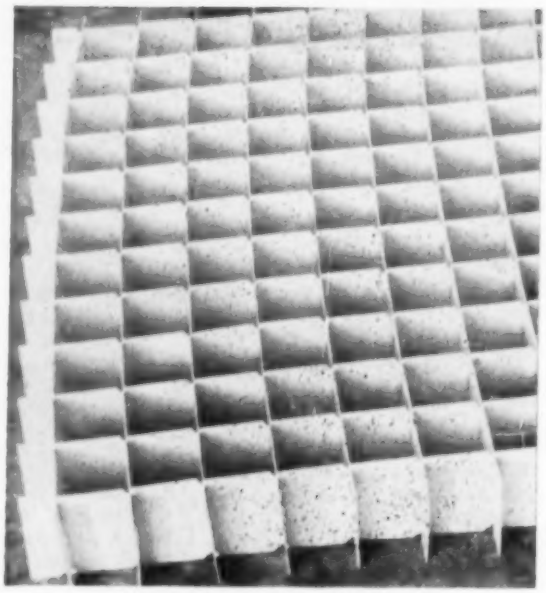


Fig. 2b. Fabricated plastic sheet packing.

The wood film packings are subject to certain limitations. One difficulty is the susceptibility of wood to chemical and biological attack under certain operating conditions. Another limitation is in the minimum thickness of members which can be tolerated. It is generally conceded that slats thinner than about 3/8 in. are not suitable for industrial tower use due to warping and accelerated deterioration problems. The maximum thickness of wood film packing members is governed by economics, and usually does not exceed 5/16 in. Because of this, it can be seen that with film packings

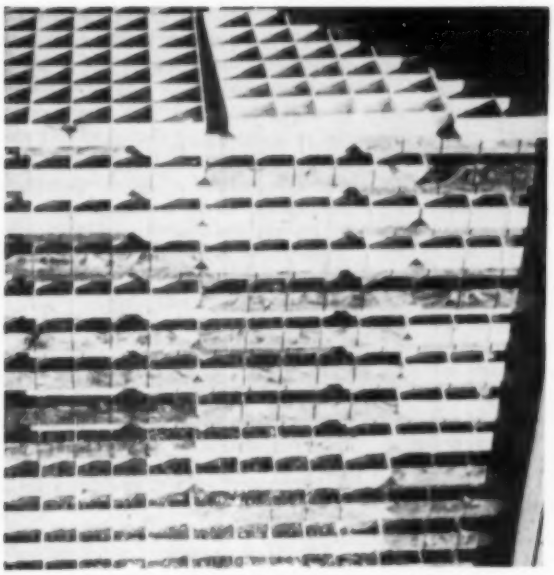


Fig. 2c. Injection molded grid without splash strips.

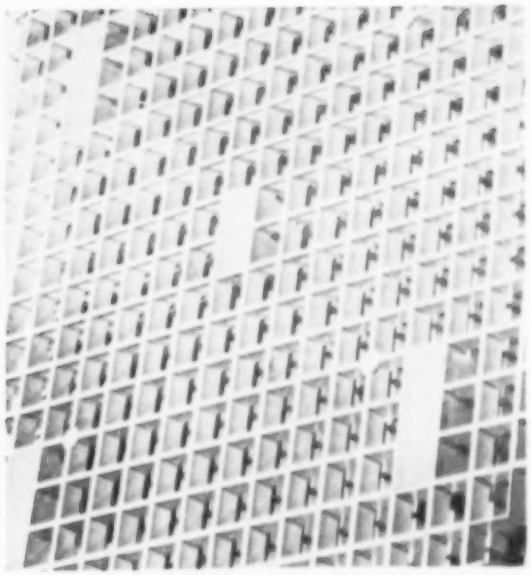


Fig. 4. Fluor Poly-Grid packing.

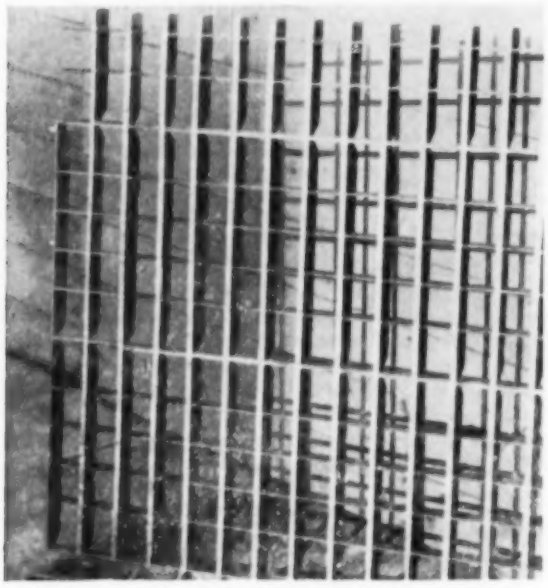


Fig. 2d. Grid packings with splash strips in one direction.

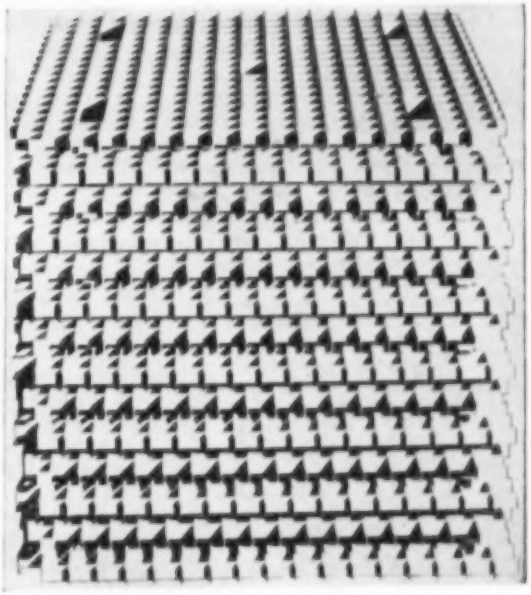


Fig. 5. Fluor Poly-Grid packing.

employing closely spaced slats (i.e., 1 to 2 in. apart), the volume of the tower occupied by lumber, and therefore unavailable for the passage of gas, may be an appreciable fraction of the total.

As a logical development of the above considerations, other materials were investigated for use in film packings which would offer advantages over wood without greatly increasing the cost of cooling towers. Among the materials investigated in this regard were cement-asbestos sheets, metal and plastic screens, plastic impregnated paper, ceramic shapes, and thermoplastic resins in several forms.

Development Studies

Early studies of materials suitable for construction of cooling-tower packing showed that the thermoplastics—polystyrene and polyethylene—offered promise from the standpoint of cost, resistance to deterioration, and adaptability to mass-production-forming techniques. Emphasis was placed on their use in high-efficiency film packings, as design and characteristics of the packing are more important with this type than with the lower efficiency splash packings. Fabrication techniques investigated included extrusion, postforming of sheet material, and injection molding. Several early plastic packing designs are shown in Figure 2.

Theoretical studies had indicated that the use of parallel vertical film surfaces should offer good performance with minimum pressure drop. In order to investigate this, a packing was developed which consisted of extruded hexagonal tubes held in a honeycomb configuration with vertical passages (Figure 2). Although this would appear to be a nearly ideal shape from the standpoint of material utilization, the packing showed serious practical limitations. To take full advantage of the extrusion techniques

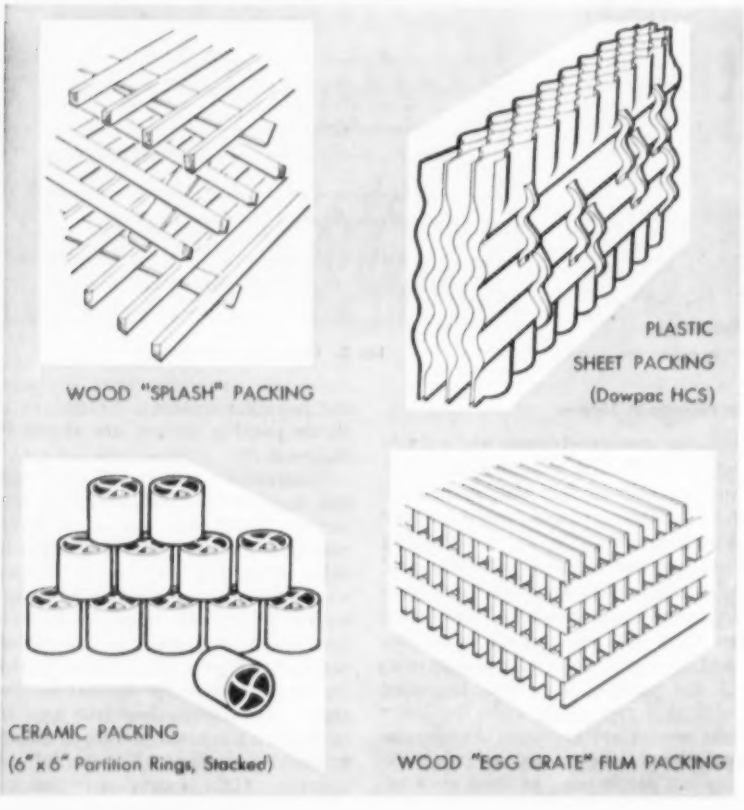
for fabrication, relatively long tubes (i.e., deep packing sections) were utilized. Experimental tests with tube lengths of approximately 4 ft. indicated that the packing performance was considerably below theoretical values. Observation of the packing during experimental tests showed that even with the efficient water distribution device employed in the research apparatus, unequal distribution of water through the various channels was obtained. As a result of this work, it was realized that with conventional water and air distribution, a packing capable of redistributing air and water within itself was a necessity.

Packings made up of a series of formed plastic sheets, such as Dowpac HCS, (*1*), see Figure 1, were tested and found to be appreciably better than the extruded-tube types, in that redistribution of air and water in at least one direction could occur within the packing unit. However, when high-efficiency packings of this type are employed, relatively shallow beds are required for most cooling-tower applications and this limited redistribution was not found to be sufficient.

It was believed that the distribution problem would be even more serious in large commercial towers where water and air distribution may be less perfect than maintained in the research apparatus. These considerations indicated the need for some vertical spacing between packing elements. Injection-molding techniques were investigated. Initial prototypes were hand fabricated to dimensions which theoretical and practical considerations indicated to be near the optimum. Several of these (including one fabricated from sheet stock) are shown in Figure 2. Various vertical spacings were investigated and it was found that a limited vertical spacing between grid decks could be used without decreasing the transfer coefficient. This spacing not only provided zones for air and water redistribution within the packing but, equally important, enabled thicker sections to be used than could economically be employed for continuous-sheet-type film packings.

Visual observation of the air-water contact in the research apparatus shown in Figure 3 (which is equipped with a transparent wall) indicated that large water drops frequently fell past several grid decks before striking one and spreading onto the packing. In order to catch these drops, splash strips were added at the top of the ribs of each deck. The strips were first attached to ribs running in one direction only, as shown in Figure 2, and this design was tested before strips were attached to all ribs of the unit. It might be added that alteration of the prototype grid decks to test this relatively simple idea required a considerable amount of hand fabrication. The splash strips were found to improve performance appreciably and, incidentally, to improve rigidity of the units, hence they were incorporated in the final commercial design.

Fig. 1. Examples of various splash and film type cooling tower packings.



Final Design

The commercial model of the plastic grid packing (Fluor Poly-Grid packing) resulting from this development work is shown in Figures 4 and 5. Patent applications have been filed on this design.

For use in large towers the units are sized approximately 3 ft. square so that four of them fit exactly into a 6-ft. × 6-ft. cooling-tower bay. Basically, the packing consists of a square gridwork of vertical ribs, 2 in. apart in both directions. Five rectangular spacers are provided on each unit. The spacers are tapered so that the packing units nest during shipping. When installed in a cooling tower, alternate layers are rotated 90 degrees so that the spacers hold the grids apart the proper distance. The rotation also serves to change the alignment of grids of alternate layers so that the ribs of one layer are not in line with those of the layers directly below or above it.

Experimental studies had indicated that this type of orientation resulted in the best performance by preventing the free fall of drops through grid passages.

Fluor Poly-Grid packing is also available in a grid having over-all dimensions of approximately 2 ft. × 4 ft. The design features are similar to those incorporated in the 3-ft. × 3-ft. unit. The 2-ft. × 4-ft. grids are designed for use in towers having a 4-ft. module, both in air conditioning and industrial service.

The packing units are injection molded in a one-shot operation. They are presently made from high impact polystyrene and a new type of linear polyethylene plastic.

The minimum water loading for completely wetting the packing surface is approximately 270 lb./(hr.)(sq.ft.). Characteristics of the packing are such that liquid loadings up to 5,000 lb./(hr.)(sq.ft.) have been successfully used.

Performance

The comparative properties and performance characteristics of the Poly-Grid and several commonly used packings for a single air and water rate are shown in Table 1. Graphical comparison of performance and pres-

sure drop of the packings included in Table 1 is shown in Figure 6.

The splash-packing curve in Figure 6 was calculated from data of Kelly and Swenson (3).

The packing E (illustrated in Figure 1) consists of nominal 1 in. × 1½ in. splash bars on 3¼ in. horizontal centers. The bars are cut on a 25-degree angle and fastened to the bottom of packing cleats so that these bars extend at a 65-degree angle from the horizontal. The decks of packing are vertically spaced 24 in. The Dowpac HCS packing (*1*) (which is shown in Figure 1) consists of individual corrugated sheets of high impact polystyrene 37½ in. long × 21 in. wide. The sheets are cemented together to form a honeycomb structure with a horizontal spacing between sheets of approximately 1 in. The FN-90 packing is a dump-type plastic packing somewhat similar in shape to Berl saddles, individual pieces having a 3¼ in. nominal diameter.

The wood film packing (*4*) consists of 2-in. × ⅜-in. slats, serrated on the bottom edge, spaced horizontally on 2-in. centers. The test data described in the paper (*4*) were from several commercial installations in England.

Data on the ceramic packing with 6-in. × 6-in. partition rings were obtained in the research test facilities shown in Figure 3 (not previously published).

In general, it can be seen that the new plastic grid packing has a high performance coefficient with a unit pressure drop comparable with that for a typical wood film packing and only slightly exceeding that for a typical wood splash type packing. In addition, it is light in weight in comparison to the other packings and has a relatively high percentage void space.

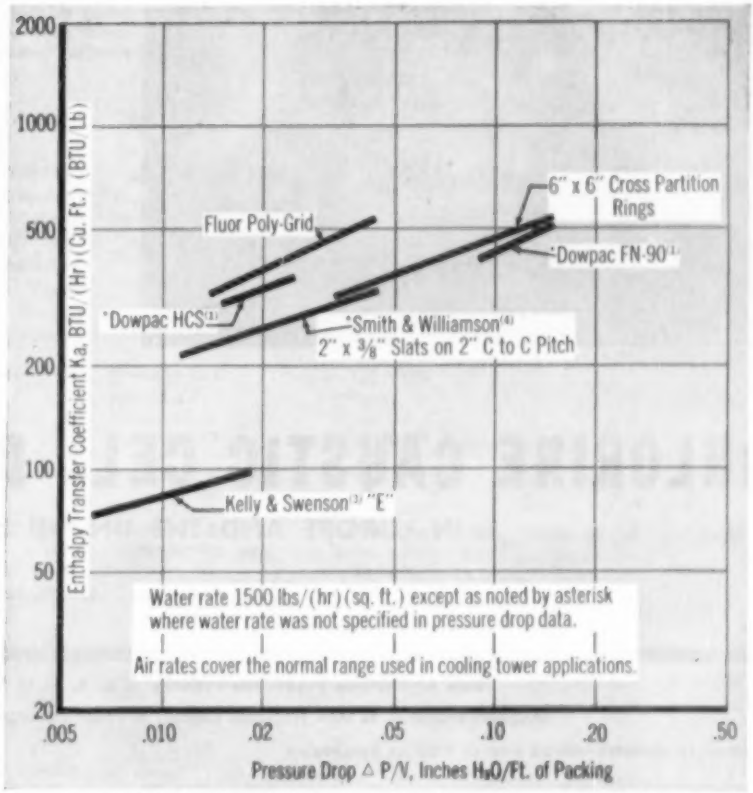


Fig. 6. Enthalpy transfer coefficient-pressure drop characteristics of various packings.

Uses

Fluor Poly-Grid packing has been developed primarily for use in water cooling towers. However, it is well suited as a gas or vapor-liquid contact medium in many other applications because of its high mass-transfer coefficient, low pressure-drop characteristics, and its relatively inert chemical structure. The open and nonclogging characteristics of the packing suggest its suitability also in the scrubbing of solid particles from air streams.

The packing is made from either high impact polystyrene or linear polyethylene. The polystyrene which is lower in cost is resistant to water and most dilute aqueous solutions including nonoxidizing acids, salts, and alkalis. It is therefore quite suitable for almost all cooling-tower applications. Polystyrene is attacked by chromic acid, nitric acid, concentrated sulfuric acid, and by most nonpolar organic solvents such as aromatics, chlorinated hydrocarbons, and ketones.

For installations where greater chemical resistance is needed, especially where hydrocarbon compounds are present in the circulating liquid, the linear polyethylene is recommended. In addition to its use for cooling towers, Fluor Poly-Grid packing appears to be suitable for biological trickling filters, chemical absorption towers, and fume, mist and dust scrubbers.

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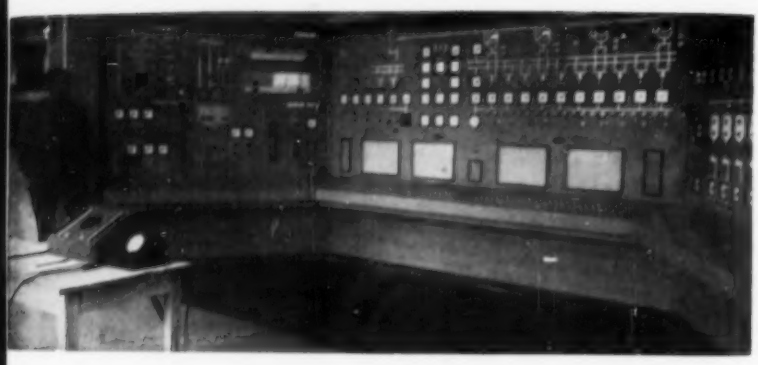
2. Fuller, A. L., *Petroleum Refiner*, 211-14 (December, 1956).
3. Kelly, N. W., and L. K. Swenson, *Chem. Eng. Prog.*, **52**, No. 7, 263-68 (July, 1956).
4. Smith, L. G., and G. J. Williamson, *Proc. Inst. Civil Engrs.*, Part 1, 5, 86-117 (March, 1956).

Table 1.—Comparison of Several Packing Types at One Air and Water Rate

L = 1,000 lb./(hr.)(sq.ft.) G = 1,500 lb./(hr.)(sq.ft.)

	Ceramic packing 6 in. × 6 in. partition rings (stacked)	Wood splash packing Kelly-Swenson packing E (3)	Wood film packing 2 in. × ⅜ in. slats on 2 in. C to C slat lower edge serrated Smith & Williamson (4)	Formed sheet packing Dowpac HCS (1)	Fluor Poly-Grid packing
Packing pressure drop $\Delta P/V$ in. H_2O/ft.	0.063	0.010	0.025	0.025	0.024
Enthalpy transfer coefficient B.t.u./(hr.)(cu.ft.) (B.t.u./lb.)	380	70	245	270	390
Weight, lb./cu.ft. (wet)	70.	0.91	9.0	3.8	2.15
% Void space installed in tower	53	98.4	81.3	94	96.7



Solvay chlorine plant control panel in four-level plant at Tavaux, France.

The accompanying exhaustive tabular compilations prepared by author Sommers cover chlorine production in the United States and Europe as of June 1, 1957. This information supplements Mr. Sommers' article in the September issue of CEP which contained impressions and conclusions gained from visits to representative chlor-caustic installations both here and abroad.

CHLORINE CAUSTIC CELL DEVELOPMENT

IN EUROPE AND THE UNITED STATES

H. A. Sommers | Air Products, Inc., Allentown, Pennsylvania

Table 1.—Chlorine Production Capacity in U. S. as of June 1, 1957

(Proposed Expansions to Show Production Capacity in 1958—capacity in short tons per day)

A. Electrolytic chlorine—NaOH and/or KOH as by-product

					Proposed expansion by 1958			
Company	Plant location	Capacity	Type of cell	No. & amps.	Capacity	Type of cell	No. & amps.	Total capacity
Allied Chem. & Dye	Baton Rouge, La.	75	Allen Moore (KML)					75
(Solvay Proc. Div.)	Brunswick, Ga.	...			260	No. Am. Solvay	88-90,000	260
	Moundsville, W. Va.	200	No. Amer. Solvay S-60	104-60,000				200
	Syracuse, N. Y.	100	No. Amer. Solvay S-60U	52-60,000				100
	Syracuse, N. Y.[a]	125	Allen Moore (KML) & Solvay Das. merc.	-16,000				125
	Total	500						760
Chlorox	Oakland, Calif.	4	Whiting merc.					4
Columbia Southern	Barberton, Ohio	225	Hooker S & Col. Sou.	12,000				225
(Pitts. Plate Glass)	Corpus Christi, Tex[a]	225	Col. Sou. (like Hooker)					225
	Lake Charles, La.	700	Hooker S-3A	840-25,000				700
	Natrium, W. Va.	600	Col. Sou. (like Hooker)		160	Uhde	70-80,000	760
	Total	1,750						1,910
Diamond Alkali	Edgewood, Md.	75	Hooker S	220-12,000				75
	Houston, Tex.	450	Diaph.-Diamond No. 2	20,000	250	De Nora 185GL	52-150,000	700
	Muscle Shoals, Ala.	275	DeNora	232-36,000				275
	Painesville, Ohio	150	Tucker-Windecker					150
	Pine Bluff, Ark.	75	Hooker S	220-12,000				75
	Total	1,025						1,275
Dow Chem.	Freeport, Tex.	200	Dow filter press					200
	Velasco, Tex.	2,300	Hooker S	12,000				2,300
	Midland, Mich.	785	Dow filter press					785
	Pittsburg, Calif.[a]	250	Dow design merc. & filter press	Merc.-12,000				250
	Plaquemine, La.	...			300	Dow filter press (?)		300
	Total	3,535						3,835
E. I. Du Pont	Deepwater, N. J.	26	Wheeler					26
Fields Point Mfg. Co.	Providence, R. I.	10	Townsend					10
Food Machinery	So. Chas., W. Va.[a]	370	Hooker S-3B & Vorce	352-30,000 720- 2,500	90	Hooker S-3B	90-30,000	460
Frontier Chem.	Denver City, Tex.	25	Hooker S	74-12,000				25
	Wichita, Kan.	200	Hooker S and S3A	12,000 & 25,000				200
	Total	225						225
General Aniline	Linden, N. J.[a]	50	Mathieson E-8	56-32,000				50

Table 1.—Chlorine Production Capacity in U. S. as of June 1, 1937 (Cont.)

(Proposed Expansions to Show Production Capacity in 1938—capacity in short tons per day)

Company	Plant location	Capacity	Type of cell	No. & amps.	Proposed expansion by 1938 Capacity	Type of cell	No. & amps.	Total capacity
Gulf Oil	Port Arthur, Tex.	17	Nelson					17
Hercules Powder	Hopewell, Va.	27	Hooker S	80-12,000	23	Hooker S3		50
Hooker Electro-chem.	Montague, Mich.	150	Hooker S-3A	150-30,000				150
	Niagara Falls, N. Y.	255	Hooker S-3, S-3A	20,000 & 30,000				255
	(formerly Niagara Alkali)[3]	150	Vorce	2,600- 1,700				150
	Tacoma, Wash.	335	Hooker S-3	500-20,000				335
	Total	890						890
International Minerals	Niagara Falls, N. Y.[3]	23	Hooker S	70-12,000				23
Jefferson Chem.	Port Neches, Tex.	...			150	Hooker S-3B	150-30,000	150
Kaiser Aluminum	Gramercy, La.	100	Hooker S-3A	120-25,000				100
Monsanto Chem.	Anniston, Ala.	30	DeNora 24Q	26-36,000				30
	E. St. Louis, Mo.	155	Hooker S-3 & Tucker-Windecker	20,000				155
	Total	185						185
National Distillers	Huntsville, Ala.[4]	100	Hooker S	300-12,000				100
Olin-Mathieson	McIntosh, Ala.	125	Mathieson E-B	116-32,000	125	Mathieson E-B	116-32,000	250
	Niagara Falls, N. Y.	120	Castner-Rocking merc.	2,000- 1,800				120
	Saltville, Va.	225	Mathieson E-B	226-32,000				225
	Brunswick, Ga.[7]	...			?	?		...
	Pisgah Forest, N. C.[4]	...						...
	Total	470						595
Penn Salt	Calvert City, Ky.	65	DeNora 24Q	52-40,000	100	DeNora 14TGL	76-40,000	165
	Portland, Ore.	100	Gibbs					100
	Tacoma, Wash.	105	Gibbs					105
	Wyandotte, Mich.[8]	225	Gibbs					225
	Total	495						595
Shell Chem. (formerly Julius Hyman)	Denver, Colo.[4]	100	Hooker S	250-12,000				100
Stauffer Chem.	Henderson, Nev.	180	Hooker S	540-12,000				180
	Niagara Falls, N. Y.	130	Hooker S-3	196-20,000				130
	Total	310						310
Velsicol (Arvey)	Memphis, Tenn.	69	Hooker S	176-12,000				69
Wyandotte Chems.	Wyandotte, Mich.	320	Hooker S-3A	380-25,000				320
	Wyandotte, Mich.	230	I.C.I. & Wyandotte	Mercury				230
	Geismar, La.	...			300	Diamond-Diaph.	360-25,000	300
		550						850
	Total	10,831			1,758			12,589
B. Pulp and paper mills—NaOH as by-product								
Brown Co.	Berlin, N. H.	58	LeSeuer & Hooker S	-12,000				
Champion Paper and Fibre	Canton, N. C.	60	Hooker S	150-12,000				
	Pasadena, Tex.	42	Hooker S	106-12,000				
	Total	102						
Eastern Mfg. Co.	South Brewer, Me.	6	Allen-Moore					
Ecusta Paper Co.	Pisgah Forest, N. C.[4]	6	Sorenson merc.	144- 1,350				
Kimberly Clark	Kimberly, Wisc.	15	Wheeler					
Murro Chem. Co.	Portsmouth, Va.	?	merc. cells					
No. Carolina Pulp and Paper	Plymouth, N. C.	12	DeNora-24Q	12-30,000				
N. Y. & Penna. Co.	Johnsonburg, Pa.	14	Hooker S	36-12,000				
Oxford Paper Co.	Rumford, Me.	13	Sorenson merc.	310- 1,350				
Penobscott Chem. Fibre Co.	Great Works, Me.	12	Larchar					
S. D. Warren Co.	Cumberland, Me.	8	Allen Moore					
W. Va. Pulp and Paper Co.	Luke, Md.	16	Hooker S	40-12,000				
	Mechanicsville, N. Y.	20	Hooker S	50-12,000				
	Tyrone, Pa.[4]	5						
Weyerhauser Timber	Longview, Wash.[9]	85	DeNora 14 TGL	66-40,000				
	Total	372						

Table 1.—Chlorine Production Capacity in U. S. as of June 1, 1957 (Cont.)

(Proposed Expansions to Show Production Capacity in 1958—capacity in short tons per day)

Company	Plant location	Capacity	Type of cell	No. & amps.	Proposed expansion by 1958 Capacity	Type of cell	Total capacity
C. Electrolytic chlorine—sodium metal as by-product							
E. I. Du Pont	Niagara Falls, N. Y.	181	Downs fused salt	190-32,000			181
	Memphis, Tenn.[7]	...			100	Downs fused salt	100
Ethyl Corp.	Baton Rouge, La.	285	Downs fused salt	300-32,000			285
	Houston, Tex.	105	Downs fused salt	110-32,000			105
	Joliet, Ill.[7]	...			?	Downs fused salt	?
	Total	390					390
National Distillers	Ashtabula, Ohio	100	Downs fused salt	100-32,000			100
	Total	671					771
D. Nonelectrolytic chemical processes							
Nitrogen Division Allied Chem. & Dye	Hopewell, Va.[3]	90	Nitrosyl chloride		90		180
Hercules Powder	Brunswick, Ga.[6]	27	HCl oxidation				27
	Total	117					207

[1] Produces $NaNO_3$ as by-product instead of NaOH. It is assumed the expansion will also; [3] produces mostly KOH as by-product instead of NaOH; [5] produces some KOH; [4] not in operation; [6] planned for ultimate capacity to 170 tons; [8] leased from Chemical Corps; [7] planning plant for 1958 operation; [9] plant reported shut down pending process changes.

Grand Total

		Capacity—6/1/57	% of total	Estimated—1958	% of total
A. NaOH and/or KOH as by-product	Diaph. cells	9,217		10,080	
	Merc. cells	1,614		2,509	
B. Pulp and Paper Mills	Diaphragm cells	256		256	
	Merc. cells	116		120	
	Total diaphragm cells	9,473	79.0	10,336	74.3
	Total merc. cells	1,730	14.4	2,600	18.7
	Total brine electrolysis	11,203		12,875	
C. Sodium metal as by-product		671	5.6	771	5.5
D. Nonelectrolytic		117	1.0	207	1.5
	Total production capacity	11,991	100.0	13,914	100.0

Table 2.—Chlorine Production in Europe as of June 1, 1957

(capacity in metric tons per day)

Company	Plant location	Capacity	Type of cell	No. and amp.
AUSTRIA				
Ebenseer Solvay—Werke	Hallein, Salzburg	40	Solvay	
Donau Chemie—A. G.	Brückl, Karnten	5		
Kellner Partington	Hallein, Salzburg	20	Solvay	
Zellstoffabrik Ley Kam-Josephsthal	Josephsthal, Steiermark	14	Billiter	
BELGIUM				
Solvay & Cie	Jemeppe	110	Solvay S-50	76-45,000
S. A. Produits Chimiques de Tessenderloo	Tessenderloo	30	BASF &	
			De Nora—modified	56-24,000
DENMARK				
Dansk Sojakage Fabrik A/S	Kobenhavn	15	Krebs merc.	12,000
FINLAND				
Finnische Chem. O. Y.	Aetsa	60 ('53)		
Enso Gutzeit O. Y.	Enso	40	Krebs merc.	12,000
Kymmene O. Y.	Kuusankoski	36	Krebs merc.	3,000-15,000
			R ϕ merc.	20,000
Ahlström	Petkarant			
Oulu O/Y Co.	Oulu	60	Krebs merc.	36,000
FRANCE				
Solvay & Cie	Tavaux, Jura	250	Solvay V-200	48-180,000
Cie. Pechiney	Saint-Auban, Basses Alpes (Group Alais, Groges & Camargue)	250	Pechiney-DeNora	Several sizes to 100,000
Ste. Progil	Pont-de-Claix, Isère	90	Hooker S & S3A	
Ste. D'Electrochimie, D'Electrometallurgie et Des Acieries Electriques D'Ugine	Jarrie-Vizille, Isère	100	Electrochimie Ugine (diaph.)	
			De Nora-14 TGL	72-45,000

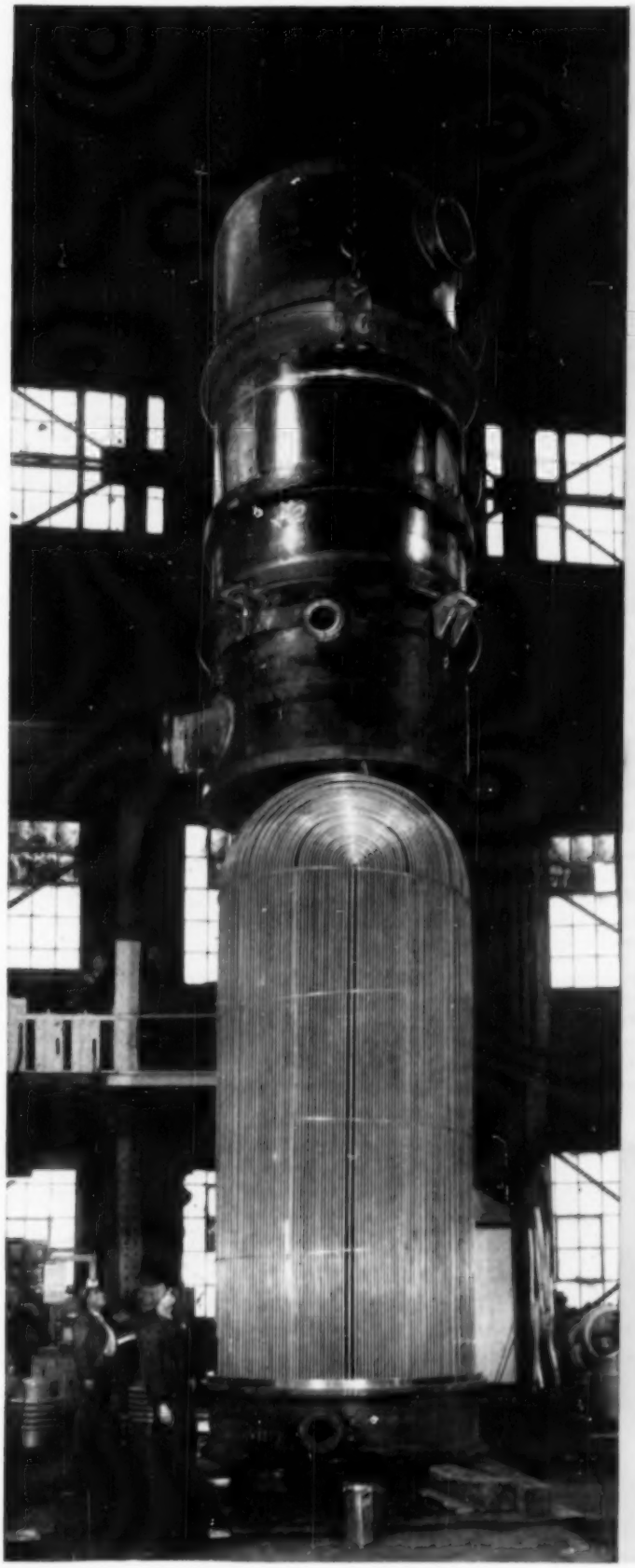
Table 2.—Chlorine Production in Europe as of June 1, 1957 (Cont.)

(capacity in metric tons per day)

Company	Plant location	Capacity	Type of cell	No. and amp.
FRANCE (Continued)				
Ste. D'Electrochimie, D'Electrometallurgie et Des Acieries Electriques D'Ugine	Pombliere-Saint-Marcel, Savoie	11	Downs sodium	30,000
Potasse et Produits Chimiques	Thann, Haut Rhin	60	J. Q.	16,000
Ets. Kuhlmann	Loos, Nord	15	Krebs-merc.	18,000
Ets. Kuhlmann	L'Estaque, Bouches du Rhône	20	Kuhlmann-diaph.	
Ets. Kuhlmann	Brignoud, Isère	7	Downs sodium	18,000
Ste. Industrielle de Produits Chimiques Bozel Maletra	L'Amotte-Breuil, Oise	40	Bozel-diaph.	4,500
Manufacture de Glaces et Produits Chimiques de Saint-Gobain	Saint-Fons	40	Krebs-merc.	18,000
Manufacture de Glaces et Produits Chimiques de Saint-Gobain	Flers-Breucq	40		
Manufacture de Glaces et Produits Chimiques de Saint-Gobain	Wasquhal, Nord	25	Hooker S	
Cie. Francaise de Matieres Colorants	Villieres-Saint-Paul, Oise	12	Krebs-merc.	9,000
Cie. Electrochimique de Centre	Bigny, Chere	4	Krebs-merc.	4,000
Ste. D'Exploitation de L'Usine de Boussens	Boussens, Hte-Garrone	12	Ugine diaph.	1,500
Soc. Des Produits Chimiques D'Harbonnieres	Harbonnieres, Somme	4	Pechiney	1,500
Ste. Rhône-Poulenc	Roussillon, Isère	10	Krebs.-merc.	10,000
Papeteries Aussedat	Cran-Gevrier, Haute-Savoie	1		
Ste. Electro-Chlore	Pujols-Sur-Ciron, Gironde	1		
Ste. Gillet-Thaon	Thaon, Vosges	0.3		
Abram	Saint-Paul-de-Fenouillet			
Chaperon Tunner	Confolens			
Benard	Lourdes			
Papeteries	Lorps, Ariège	0.1		
Cellulose du Rhône	Tarascon	15	Krebs.-merc.	10,000
Lemaire-Destombes	Saint-Andre-Les-Lillie, Nord	10	Krebs-diaph.	
GERMANY—EASTERN				
Chemische Werke Regethan	Loderberg (near Bitterfeld)	20	Krebs-merc.	
Chemische Werke G.m.b.H.	Zscherndorf (near Bitterfeld)			
Zellstoff Werke Pivna	Pivna (Saxony)			
Chemische Fabrik von Heyden A. G.	Radebul (near Dresden)	30	Aussig & Krebs-merc.	
Feldmuhle Papier	Odermunde (near Stettin)	12	diaph.	
Electrochemische Kombinat (believed transferred to U.S.S.R.)	Bitterfeld	140	diaph. & J. G. merc.	
Electrochemische Kombinat	Schkopau	120	J. G. merc.	
Zellstoffwerk	Pernia			
Electrochemische Werke	Ammendorf	40	Siemens diaph.	
Deutsche Solvay Werke	Westeregeln / Osternienburg	60	J. G., Solvay merc., and diaph.	
GERMANY—WESTERN				
Dr. Alexandre Wacker Gesellschaft fur Elektrochemische Industrie G.m.b.H.	Burghausen	100	J. G. & Wacker merc.	30,000
Chemische Fabrik E. Merck	Darmstadt	12 ('55)	merc.	10,000
Anorgana	Gendorf	150	BASF-merc.	12,000 & 16,000
Lech-Chemie Gersthofen	Gersthofen	83 ('55)	Gersthofen merc.	
Farbwerke Hoechst A. G.	Hochst-am-Main	215	Hoechst merc.	147-20,000 64-40,000 42-45,000
	Gendorf	95	Hoechst merc.	190-17,000
	Gersthofen	97	Hoechst merc.	176-19,000
Zellstoffabrik Wadlhof	Kelheim	10 ('55)	Krebs-diaph.	6,000
Deutsche Gold-Und-Silber Scheideanstalt	Knapsack	43 ('55)	sodium	
Farbenfabriken Bayer A. G.	Leverkusen	260	merc.	220-40,000
Farbenfabriken Bayer A. G.	Bayerberk	283 ('55)	merc.	
Badisch Anilin-Und Sodafabrik	Ludwigshafen	200	merc.	6,000, 12,000, 30,000 40,000 & 100,000
Feldmuhle A. G.	Lulsdorf	120 (80KOH) (40NaOH)	Lulsdorf	105-38,000
Chemische Werke Hüls G.m.b.H.	Marl	200	rotating cathode merc.	175-35,000
Dynamit A. G.	Rheinfelden	60	Billeter	
		20	merc.	
GREAT BRITAIN				
Imperial Chem. Industries Ltd.	Billingham, Durham	100 ('55)	Gibbs, fused salt & merc.	
	Hillhouse, Lancs.	210 ('55)	Gibbs	
	Rocksavage, Ches.	50 ('55)	I.C.I. merc.	
	Runcorn, Ches.	500 ('55)	I.C.I., merc., fused salt	
	Widnes, Lancs.	200 ('55)	Gibbs	
	Wilton, Yorks, N. R.	50 ('55)		
	Northwich, Ches.	60 ('55)	Gibbs	
Murgatroyd's Salt & Chem. Co.	Elworth, Ches.	45	Hooker type S	
		50	Uhde merc.	
The Staveley Coal & Chem. Co. Ltd.	Staveley, Derby	50	Stavely Krebs merc.	
L. Dennis	Walkden, Lancs.			
Monsanto Chem. Ltd.	Newport, Monmouth	24	DeNora 16T	50-16,000
Associated Ethyl Co., Ltd. (under const.)	Ellesmere Port, Ches.	200	BASF—Du Pont fused salt	30,000
Glamorgan Alkali & Acid Co., Ltd.	Pontypridd, Monmouth	11	De Nora—14 DGL	16-24,000

Table 2.—Chlorine Production in Europe as of June 1, 1957 (Cont.)
(capacity in metric tons per day)

Company	Plant location	Capacity	Type of cell	No. and amp.
GREECE				
Elektrokhemike Heliados A. E.	Aspropyrgos			
ITALY				
Societa Chimica Dell'Aniene	Rosignano	145	Solvay—V100 (2 levels)	100,000
Societa Chimica Dell'Aniene	Ponte Mammolo			
Soc. Industrie Chimiche Edison (S.I.C.E.)	Porto Maghera	110	De Nora 24T	128-30,000
S. A. Chimica ed Elettrochimica del Caffaro	Brescia	40	Kellner	
Soc. Generale per L'Industria Minerario e Chimica Montecatini	Bussi	60	De Nora—modified	
Istituto Poligrafico dello Stato	Foggia	8	Pomilio	
Azienda Colori Nazionali ed Affini (ACNA)	Cesano Maderno	10	merc.	
Industrie Chimica Dr. Saronio	Melegnano	15	merc.—10,000 De Nora—6,000	
Azienda Colori Nazionali ed Affini (ACNA)	Cengio	5		
Stabilimenti di Rumianca	Apuania	40	Krebs	
Stabilimenti di Rumianca	Pieve Vergonte			
Soc. Elettrochimica Solfuri e Cloroderivati	Tavazzano	42	Achille-merc.	
Soc. Agricola Industriale per la Produzione Italiano di Cellulosa (S.A.I.C.I.)	Torviscosa	21	De Nora	
Applicazione Processi Elettrochimici (A.P.E.)	Vado Ligure	30	De Nora-14DGL	32-30,000
Cellulosa dell'Italia (Celdit)	Chieti	10 ('46)	Pomilio	
Gori	Bergamo	2 ('24)	De Nora-diaph.	2,200
Cartiera di Tolmezzo	Tolmezzo	15	Krebs	
Industrie Chimiche Dr. Baslini	Treviglio	4 ('35)	De Nora	1,000
Soc. Industrie Agricole	Mantova	200	De Nora—14 TGL	156-45,000
NETHERLANDS				
N.V. Nederlandsche Patent-En Kristal Sodafabriek	Linne-Herten	145	Solvay	48-V100-90,000 (4 levels)
		85	Solvay	70-V40-40,000
Koninklijke Nederlandsche Zoutindustrie	Hengelo	100	Hooglund merc.	25,000
Koninklijke Nederlandsche Zoutindustrie	Djelfiel	65	De Nora 14 TGL	48-45,000
NORWAY				
Saugbrugsforeningen	Halden	10	Krebs diaph.	
Herøya Elektrokjemiske Fabrikker A. S. (H.E.F.A.)	Herøya	25	BASF merc.	15,000
A. S. Borregaard	Sarpsborg	60	Krebs	
A. S. Toten Cellulosefabrikk	Toten	10	Toten	
SPAIN				
Solvay & Cie	Torrelavega	20	Solvay	
Electro-Quimica de Flix	Flix	50	I.G.	
Papelera Espanola	Valencia			
Soc. Electrolitica Espanola S. A.	Bilbao, Derio	12	Krebs	
Electroquimica de Hernani	Hernani			
Cia. Aragonsea de Industrias Quimicas	Sabinanigo	4	Krebs—I.G.	
Gea Cobo	Andujar			
Derivados Electroquimicos de la Sal	Zaragoza			
Industria Quimica del Nalon	Trubia			
Electro-Quimica de San Miguel	Lataso			
Fabrica Nacional de Colorantes y Explosivos S. A.	Guardo	6	Krebs	
Hijo de Casamitjana	Barcelona			
Electroquimica Papelera	Cegama			
Cia de Industrias Electroquimicas	Badalona			
Cia de Industrias Electroquimicas	Gerona			
Electro-Quimica Santa-Rita	Gijon			
Electro-Quimica del Ebro	Logrono			
Sucesores de Carlos Andres S. L.	Logrono			
Etinoquimica	Monzon	10	De Nora 16T	24-16,000
SWEDEN				
Mo Och Domsjo A. B.	Ornskoldsvik	80	Krebs merc.	
Elektrokemiska A. B.	Bohus	40	Krebs-Bohus (KOH)	
Uddeholms A. B.	Skoghall	80	Kjeligken	
Stora Kopparbergs Bergslags A. B.	Skutskar	60	I.G.	
Svenska Cellulosa A. B.	Ostrand	180	Olson	
SWITZERLAND				
Schweizerische Sodafabrik	Zurzach, Aargau	30	Solvay V-40	
Cellulosefabrik Attisholz	Attisholz, Solothurn	20	Krebs merc.	
S. A. Pour La Fabrication De Magnesium	Martigny, Valais	10	Krebs & De Nora	
Cie. Pour L'Industrie Chimique a Brie (C.I.B.A.)	Monthey, Valais	20	C.I.B.A., diaph.	
Ste. Pour L'Industrie Electrochimique	Turgi, Aargau	5	Lescowitz merc.	
TURKEY				
Sumerbank Selluloz Sanayii Muessesesi	Izmit Kutahya			



YUBA

A GREAT NEW NAME IN HEAT EXCHANGERS

▶ The name YUBA now appearing on heat exchangers all over the country is new. But the plants in Pennsylvania, New York and California which make YUBA heat exchangers are old in experience. Some have been designing and manufacturing heat transfer equipment for more than half a century.

For example, the YUBA Heat Transfer Division was formerly the Heat Exchanger Division of the world-famous Lummus Company; the Calsteel Division has established its own well-recognized name in the West; and the Adsco Division includes the former Alberger Heater Company.

YUBA's experience is, therefore, YUBA's assurance to its customers that the heat exchangers they order are expertly designed for required operating pressures and temperatures and for maximum heat transfer.

Take, for instance, the mammoth exchanger shown at the left, one of four built at the Buffalo Plant. The customer asked for a corrosion-resistant exchanger with tremendous capacity for a secret process. YUBA built this giant which weighs 50 tons, has 12¼ miles of tubing with 14,000 sq. ft. of heat transfer surface. The welding of the 16-ton copper silicon shell attracted industry-wide attention.

Consult YUBA when ordering heat exchangers and benefit from YUBA's vast experience and East-West facilities.

YUBA

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Shut down major chemical, synthetic gasoline plant

Amoco Chemicals will close down its Brownsville, Texas, unit (first opened in 1950 by ill-fated Carthage Hydrocol, Inc.) where synthetic gasoline and chemicals were produced from natural gas. Layoffs began October 1, only the natural gas producing unit will continue to operate.

Major engineering problems and their solution revealed in detail in final engineering evaluation of the experimental plant.

Claiming a technical success but an economic failure (estimated $5 million reduction in net earnings for 1957, offset partially by elimination of the operating losses and heavy capital expenditures involved in trying to make the plant economic), Amoco Chemicals is shutting down its commercial size, but experimental, plant. While the process proved technically possible, it could not produce gasoline and chemicals from natural gas as cheaply as they can be produced by other processes.

The plant, originally completed in 1950 by Carthage Hydrocol (aided by an RFC loan of $18.5 million), was designed to convert 90 million cu.ft. of natural gas and 280 million cu.ft. air/day into 6,000 bbl. of gasoline, 900 bbl. of diesel fuel, 200 bbl. of fuel oil, and 300,000 lbs. of chemicals. Plagued by process and mechanical problems, the plant never achieved more than 30 per cent of design production.

In June, 1953, it was shut down by Carthage Hydrocol, turned over to RFC, and finally purchased by Stanolind Oil and Gas (now Pan American Petroleum Co.), an affiliate of Standard Oil (Ind.), which had worked with the process, had a chemical processing plant nearby, thought it could succeed where Hydrocol had failed. Stanolind later changed the name of the plant operating company to Hidalgo Chemical Co. which was incorporated into Amoco Chemical Co. when Standard Oil (Indiana) consolidated its chemical operations under that name.

When Stanolind took over the plant in 1954 intensive and extensive engineering work was necessary and The Lummus Co. was selected to carry it out.

Despite considerable improvement in the performance of the synthesis reaction section as compared to that obtained by the previous owners (Carthage Hydrocol, Inc.), the most difficult problems were encountered in that section:

- **Mechanical failure and unsatisfactory operation of the filters used to separate entrained catalyst from the reactor effluent gases.**
- **Failure to obtain the highly efficient gas-solids contacting desired in the reactors.**

These problems necessitated extensive technical study and plant-scale testing. The first problem was completely solved several months ago. The second problem appears to have been solved as indicated by tests in a plant reactor of intermediate size. The results of that work were being translated to the large reactors when economic considerations dictated shutdown of the plant.

Synthetic Fuels Plant section at Brownsville, formerly owned by Carthage Hydrocol, Inc.

The Process

The hydrocarbon synthesis process is based on the reaction of carbon monoxide and hydrogen in the presence of powdered iron catalyst to produce a variety of hydrocarbons and oxygenated chemicals. Raw materials for the process are oxygen and natural gas (essentially methane). Oxygen is obtained by fractional distillation of liquid air at very low temperatures (about −300° F.). Natural gas is obtained from nearby gas fields.

Synthesis gas (a mixture of carbon monoxide and hydrogen) is produced by partial oxidation of the natural gas with oxygen of 95 per cent purity. This "controlled partial combustion" step is performed without the use of a catalyst at a pressure of about 300 lbs./sq.in., and at temperatures in the range of about 2,500 to 3,500° F.

The iron catalyst used in the synthesis reaction step is derived from mill scale (obtained from steel mill rolling operations). The mill scale is properly ground, sized, and impregnated with a chemical promoter. The resulting material is reacted with hydrogen under suitable conditions, producing powdered iron of relatively high purity. The final step in preparation of the catalyst is treatment with synthesis gas under carefully controlled conditions. This is termed "activation."

The synthesis reaction step, where the carbon monoxide and hydrogen are reacted in the presence of the catalyst, is conducted at a pressure of about 400 lbs./sq.in. at a temperature of approximately 600° F. The catalyst is maintained in a "fluidized" state by upward passage of gases through the reactor. The heat of reaction must be removed to maintain the desired temperature.

Crude mixed products of the synthesis reaction—light gases, hydrocarbon liquids, and crude chemicals dissolved in water—are sent to their re-

(*Continued on page 52*)

The Trend is to **WESTFALIA**

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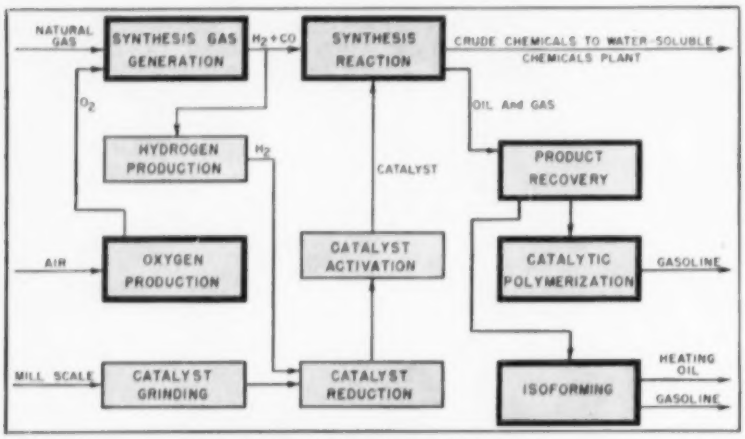
BROWNSVILLE SHUTDOWN (*Continued from page 50*)

spective processing areas. The light olefins are treated in a conventional catalytic polymerization unit to produce gasoline products. The synthetic oil stream is refined in a fluid catalytic cracking unit to obtain high ultimate recovery of gasoline. The water-soluble chemicals are separated and purified in an adjoining plant originally built by Stanolind.



Flow diagram—hydrocarbon synthesis process.

MAJOR ENGINEERING PROBLEMS AND THEIR SOLUTION

Oxygen Production

The oxygen plant consists of two identical units, each having a capacity of approximately 1,000 tons/day of gaseous oxygen of 95 per cent purity. Major modifications made during the construction period were:

- **Repair of insulation. The oxygen plants operate at temperatures as low as —300° F. High heat leaks experienced by Carthage had limited oxygen production to about 75-80 per cent of design.**
- **Revisions in the heat exchanger system and addition of one new exchanger to each unit.**

Numerous other changes of lesser importance were made to provide better process control and improve oxygen recovery.

Synthesis Gas Generation

The partial combustion of natural gas with oxygen was one of the pioneering steps of the hydrocarbon synthesis process. Wartime advances in the manufacture of oxygen, together with the simplicity of the basic process of combustion, provided the impetus for this development.

The original Brownsville plant included only one gas generator for the production of synthesis gas. Repeated burner failures, soot deposition on the tubes of the cooling section, refractory failures, and other problems seriously limited operations by Carthage. With no spare unit, the entire plant was forced to shut down whenever the gas generator failed. To provide continuity of operations, a second gas generation unit, having many design improvements, was installed by Pan American. Both the old and the new generators were equipped with new, improved burners in which the natural gas and oxygen were combined to produce the synthesis gas. One important factor in the burner modifications was the addition of multiple burner control systems to permit accurate control of gas and oxygen. Maintenance of proper oxygen-to-gas ratio is important —otherwise, at high oxygen ratio, excessive flame temperature results, leading to metal and refractory failures. At low oxygen ratio excessive soot formation occurs. The control system was analyzed in an analog computer study to insure proper operation of this very critical part of the unit. Initial operation of the new gas generator occurred in April, 1956. Although the unit operated successfully for 111 days prior to shutdown, a number of important problems were encountered. These include:

- **Excessive soot formation, resulting in carbonaceous deposits on the burners.**
- **Failure of certain parts of the burner due to corrosion.**
- **Failure of the burner face refractory with exposure of the burner to excessive flame temperatures.**

These problems, together with several other less important problems, were overcome and operation of the generator at rates and product yields substantially above design became routine.

Catalyst Preparation

This system includes units for grinding, sizing, and chemical impregnation of powdered catalyst followed by reduction with hydrogen and treating (activation) of reduced catalyst with synthesis gas. A number of important revisions were made in the catalyst grinding and sizing unit and no serious difficulties were encountered in obtaining satisfactory operation.

The catalyst reduction step, in which the unfinished catalyst is contacted with hydrogen under fluidized conditions, was modified as follows:

- **New reactor internals were provided to insure better gas-solids contacting.**
- **A filter system was installed for recovery of catalyst fines from the reactor effluent gases.**

The desired improvement in gas-solids contacting was obtained during early stages of operations by Pan American. However, considerable difficulty was encountered with the catalyst filter system. In general, this problem is similar to that which occurred in the synthesis reaction step. From an over-all viewpoint, all performance goals for the catalyst reduction unit were met or exceeded.

Synthesis Reaction

The synthesis reactors are the heart of the hydrocarbon synthesis process. The plant includes two 16.5-ft. diam. reactors. In normal operation, each reactor contains 175-200 tons of catalyst in a fluidized bed. Each reactor is equipped with multiple catalyst filters to separate entrained catalyst fines from the gaseous reactor products. Associated equipment includes heaters, compressors, and heat exchangers, as well as catalyst storage and handling facilities.

This unit was extensively modified and important new equipment was added during the engineering and construction period. These changes were based largely on laboratory and pilot plant studies by the Pan American research organization. Major modifications included:

1. Replacement of the feed gas distributor and the reactor internals employed for removing the heat of reaction, in order to obtain better gas-solids contacting.
2. Installation of a new system for removal of the large quantities of heat released by the synthesis reaction. The original cooling system consisted of "bundles" of steam tubes capable of generating steam at 675 lb./sq.in. (500° F.). The only means of control was

(*Continued on page 54*)

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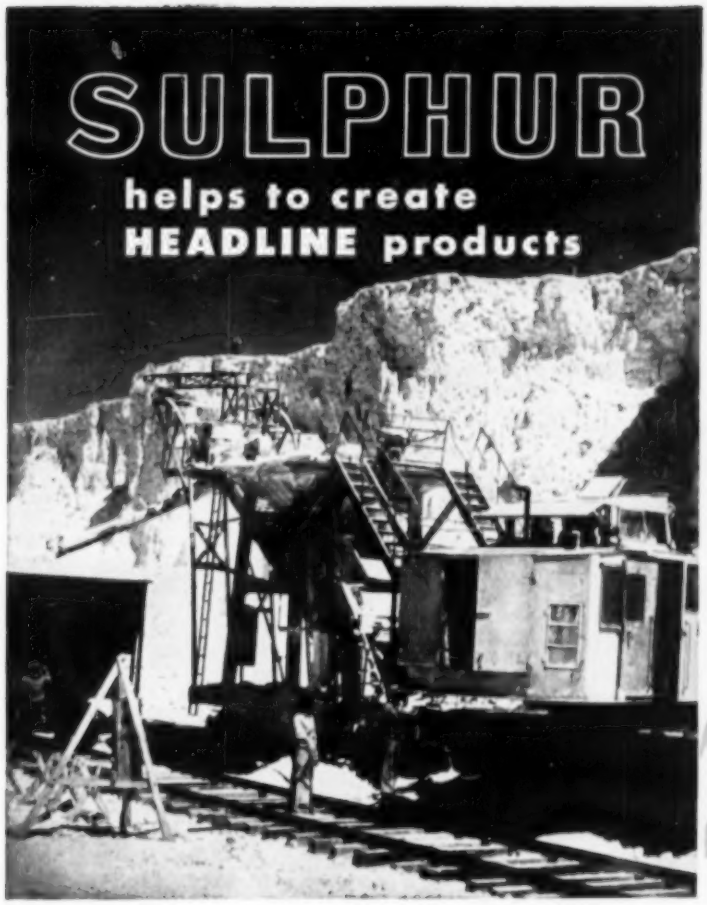

Thiokol®

"Thiokol" synthetic rubber, is an organic polysulfide elastomer. One of its many uses is in solid propellents for long range and high altitude missiles. In liquid form, "Thiokol" synthetic rubber mixed with an oxidizer, is poured into specially designed combustion chambers of rockets. It helps to give stability to the fuel charge and resistance to shock. It promotes uniform burning. When the rocket motor is ignited the mixture burns with great intensity and generates large volumes of gas to propel the rocket.

Solid propellents made with "Thiokol" synthetic rubber have proved their value in rockets over liquid propellents in many ways: they are less costly and easier to manufacture—simple and rugged construction makes handling and launching easier and safer—fuel tanks and complicated feed systems are eliminated.

"Thiokol" synthetic rubber is a product containing a high percentage of Sulphur—its name being derived from the Greek words for sulphur and glue. Here is another example of the continually broadening field in which Sulphur is an important and necessary element.

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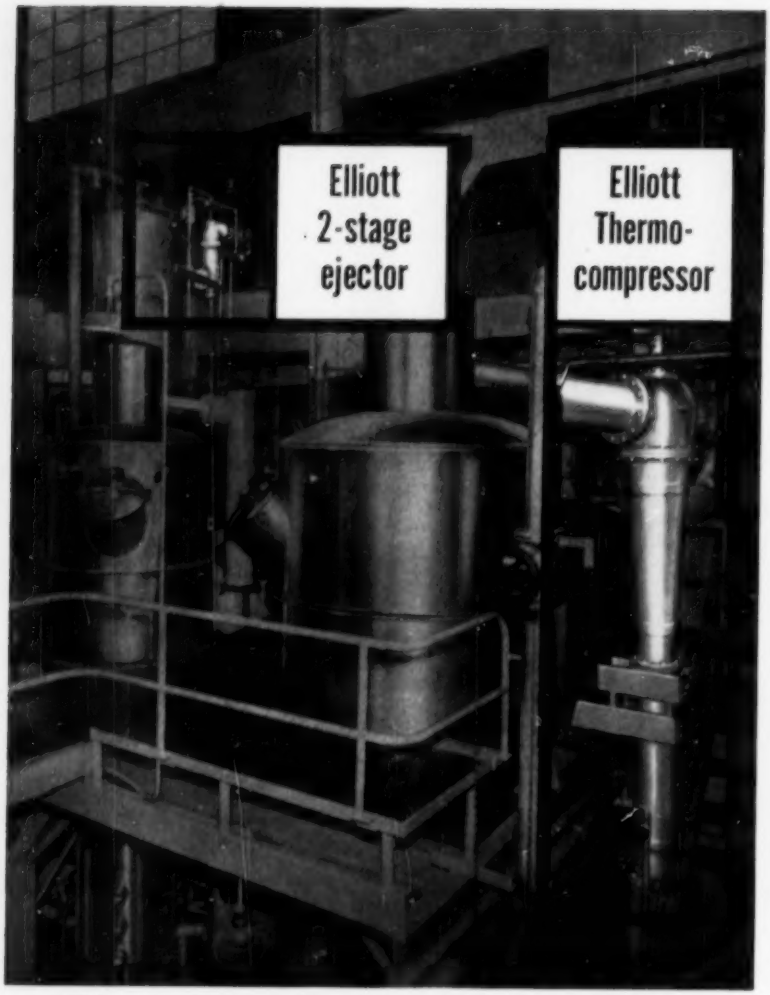

Thermo-compression provides ECONOMY and EFFICIENCY in evaporation process

In the installation shown above may be seen (right) a large Elliott thermo-compressor in vertical position, and (left) an Elliott two-stage ejector serving a condenser.

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This is accomplished by the use of a thermo-compressor, using the energy of the boiler steam supplied to the evaporator, to entrain and compress the low-pressure spent steam, for re-use in the same body or effect. A thermo-compressor is similar to and operates on the same principle as the steam jet ejector; pressure levels are dictated by the design of the particular evaporator.

The experience of the Elliott engineering staff is available to assist in investigating applications for this thermo-compression process.

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BROWNSVILLE SHUT-DOWN

(*Continued from page 52*)

to vary the water flow to individual tube bundles. With this system, catalyst bed temperature control was poor and reactor "hot spots" were encountered. Pan American installed a system which allowed variable steam pressure control over the range 675-1,500 lb./sq.in. (500°-600° F.). This change allowed more precise control of the reactor temperature which is necessary for satisfactory catalyst life and good product yields.

3. Replacement of cyclones and addition of filters for separation of entrained catalyst fines from the effluent gas. In the Carthage installation, each reactor was provided with two-stage cyclones. Catalyst recovery was poor with resulting carry-over into the heat exchanger system The new single stage cyclones installed by Pan American were of highest possible efficiency. The filter system installed for each reactor was designed with four separate filter vessels containing porous metal filtering surfaces. Each vessel was provided with automatic valves to permit periodic reversal of flow in order to remove accumulated filter cake.

4. Modification of the heat exchange equipment to provide for heat recovery from the reactor effluent gas.

Initial operation of a synthesis reactor occurred in June, 1956. The major problems encountered since that time include:

1. Failures of the porous metal used in the catalyst filters, clogging, and other difficulties in the operation of the filter system.

2. Much poorer gas-solids contacting efficiency than design, resulting in catalyst deposition on the reactor internals.

3. Erosion of reactor internals.

4. Excessive catalyst losses.

Until recent months, the porous metal filters appeared to be the major limitation in reactor operation. The several aspects of this problem included:

1. Mechanical failures which allowed catalyst to pass through the filters and into the heat exchange equipment located downstream of the reactor. This resulted in malfunctioning of the heat exchange system.

2. Catalyst accumulation among the individual "bayonets" in each filter vessel (a bayonet is about 4 ft. long and its cross section is elliptically shaped and about 2½ in. wide), resulting in complete packing of catalyst within a filter vessel.

3. Carburization and embrittlement of the porous metal (Type 316 stainless steel) used in the filter bayonets as a result of reaction with the carbon monoxide in the reactor effluent gas.

During this stage of operations, reactor operating factor was about 30-35 per cent.

The filter problem was solved by the

(*Continued on page 56*)

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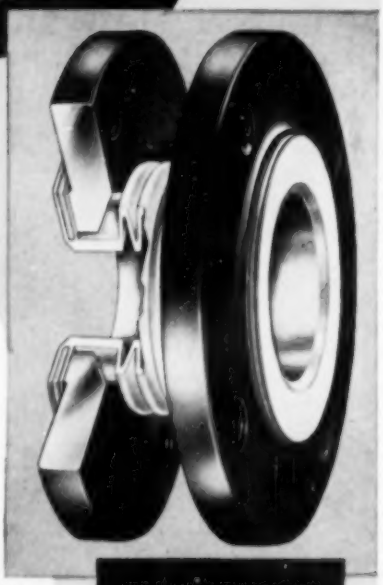
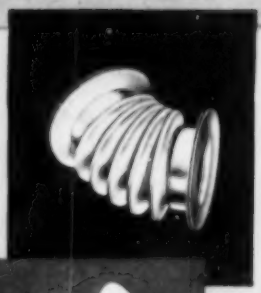
*"John Crane" fabricated from DuPont Teflon



When it is a question of handling corrosive fluids in processing or hydraulic equipment —Chemlon Connectors best meet the need. They are fabricated from the most chemically resistant material available, DuPont Teflon. The most destructive acids, corrosives and solvents have no deteriorating affect.*

Other important advantages are their long service-life, extreme flexing ability and wide temperature range from −65°F. to +350°F.

Chemlon flexible pipe connectors offer a definite plus value construction-wise. 1) They are made from Teflon specially fabricated for high and uniform density. 2) An exclusive manufacturing method assures uniform wall thickness throughout the convoluted area. 3) They are formed at full free length to reduce residual and working strain to an absolute minimum.



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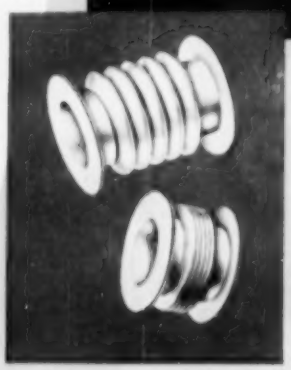

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BROWNSVILLE SHUT-DOWN

(*Continued from page* 54)

use of modified operating conditions to minimize some of the undesirable effects, and by the development of a new type of filter medium to replace the porous metal originally used in the bayonets. The new filters employed glass fibers in conjunction with carbon steel. With the revised filter system, sustained operation of the reactors was possible and filter maintenance costs were reduced to a satisfactory level.

With some minor differences, the filter problem is common to the reduction, the activation, and the synthesis reaction systems. The solution to the filter problem developed for the synthesis reactors was successfully applied to the reduction and activation units.

Despite the considerable improvement over earlier Carthage operation, deposition of catalyst on certain of the reactor internals, the presence of hot spots, and high catalyst fines production rates were experienced from the start of reactor operations. In addition, erosion of the reactor internals was an important problem in some early runs. Numerous detailed changes were made to the plant reactors to overcome these difficulties.

Overall Problems

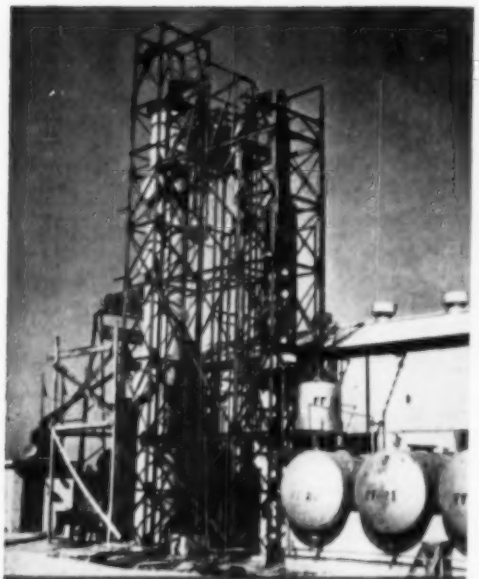
Results from a typical plant run were:

Length of run, days	50
Feed rate, per cent of design	100
Average yields, per cent of design	
Water-soluble chemicals	90-95
Stabilized oil	80-85
Polymer gasoline	80-85

At the time of shutdown, reactor operating factor was indicated to be about 60-65 per cent. Although the actual reactor performance was somewhat below design expectations, the performance was considered acceptable for this particular stage of development of the process. Data obtained from the operations indicate that most of the differences in past reactor operations as compared to design result from deficiencies in the gas-solids contacting within the reactor.

The activation reactor is a smaller (8 ft. diam.) unit which is capable of being operated as a synthesis reactor. For several months, the basic problem of gas-solids contacting was investigated in this reactor. Revisions were made to the reactor internals whereby significant improvements in gas-solids contacting were achieved, as shown by

(*Continued on page* 80)



Reactor containing chlorinated organic solvents and concentrated HCl at 280°F. Duro-Line membrane protected with brick jointed with Lecite.

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Nitro-Dur — Epoxy Base
Duro-Kote — Polyvinyl Chloride Base
Kemitite — Asphalt Base
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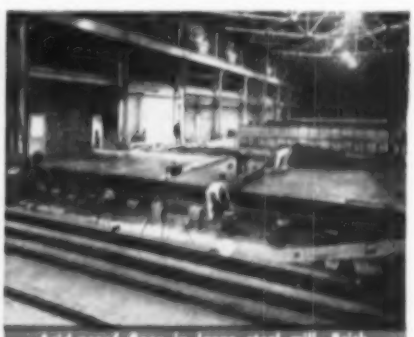
*Trade name — E. I. du Pont de Nemours †Trade name — Minnesota Mining & Mfg. Co.

Duro-Prene lined steel tanks handling acid wastes.

Duro-Ware P.V.C. duct handling acid fumes.



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SODIUM BOROHYDRIDE PRODUCTION STARTS AT METAL HYDRIDES PLANT

New $5,400,000 facilities at Danvers, Mass., will make tonnage quantities of critical rocket fuel intermediate for Olin-Mathieson's high-energy fuel plant at Niagara Falls.

A new semi-continuous process developed and piloted by Metal Hydrides will turn out $9,200,000 worth of sodium borohydride over the next 18 months under the terms of a Navy contract. The product will go to Olin-Mathieson's Niagara Falls, N. Y. plant for conversion into high-energy, boron-containing fuels. Capacity of the plant, while officially undisclosed, is claimed to represent the largest production rate of any plant of its type in the Free World, can be estimated at somewhere between 3 and 5 tons/day.

View of trimethyl borate plant area. To left are boric acid hoppers; right, fractionating columns.

Process

The process employed is said to be a marked advance over the dry process formerly used. A 5 to 25 micron dispersion of sodium hydride in mineral oil can be pumped and metered, making possible an economic semi-continuous operation. The oil makes for safety, speeds up the reaction, and acts as a heat sink for heat transfer purposes. Basic raw materials for the process are propane (converted into high-purity hydrogen in a standard Girdler-designed unit), metallic sodium (shipped into the plant in tank car lots), and boric acid. Badger Manufacturing, Cambridge, Mass., acted as overall design and engineering contractors for the plant.

Operating labor for the new plant, a serious problem in the Boston area, is being trained in a unique training program set up by Metal Hydrides with the assistance of Northeastern University.

Cost

Metal Hydrides's investment in the plant is about one million, representing the site, improvements, rail sidings, and all buildings. Equipment was paid for by the government to the tune of about $4,400,000. However, Metal Hydrides is not putting all its eggs in the present Navy contract basket. Other industrial applications of sodium borohydride are being energetically explored. They are said to include: treatment of wood pulp, modification and stabilization of cellulose, and foaming of plastics such as vinyl chloride and epoxy resins.

DOW GOES INTO ZIEGLER POLYETHYLENE; USI INTERMEDIATE POLYETHYLENE PLANT AT HOUSTON

Joining the rapidly growing polyethylene surge, Dow will build a low-pressure, Ziegler linear plant, while USI has firmed the location of its to-be-constructed intermediate density plant as a site on the Houston Ship Channel owned by Phillips Petroleum.

Dow's entrance into the low-pressure, linear polyethylene field will be made with the construction of a multi-million dollar plant at the company's Bay City, Mich., division.

Scheduled for completion in October, 1958, Dow's plant will use a Ziegler process under license, will get its raw materials from its own petrochemical plants and from the Bay City Refining Corp., a wholly-owned subsidiary. The plant will produce powder and granular material in its natural white and in other color formulations.

Dow's product has had extensive pilot plant preparation for the last two years, will represent a major effort in the field.

USI At Houston

The 75 million lb./yr. plant of USI's subsidiary National Petro-Chemicals Corp. will definitely be located on the Houston Ship Channel, will get its high purity ethylene from Phillips Petroleum's new ethylene plant at Sweeny, Texas, under long-term contract. The ethylene will be piped the 70 miles from Sweney, will be purified by Phillips at Adams Terminal before delivery to USI. Phillips will also supply the plant's natural gas requirements.

Scheduled for operation in late 1958, the new USI plant is being engineered and constructed by M. W. Kellogg.

Billion-Pound-a-Year

Both companies are convinced that the high interest and potential use value of both linear low-pressure polyethylene and the intermediate density high-pressure product will quickly boost all polyethylenes into the category of the first billion lb./yr. plastic.

PROCESS INDUSTRY APPLICATIONS MAJOR TARGET OF CONSIDERATION IN TITANIUM-ZIRCONIUM INDUSTRY

Merger of all the titanium, zirconium and other "special metal" production and fabrication facilities of National Distillers and Chemical, Sharon Steel, and P. R. Mallory & Co., into one new company to be named Mallory-Sharon Metals Corp., has commercial, non-nuclear, non-military uses as a major target for the future.

The largest single company in the so-called "special metals" industry is expected to be a legal, operating reality before the end of the year when the new Mallory-Sharon Metals Corp., jointly owned by Sharon Steel, National Distillers, and P. R. Mallory, will go into production with assets exceeding $55 million, net worth of about $32 million.

Result: A completely integrated special metals company with the technical know-how and facilities for every step from original chemical processing to production and fabrication of finished products. The former jointly-owned (by Mallory and Sharon Steel) Mal-

(Continued on page 60)

This installation in the De Laval Steam Turbine Company in Trenton, N. J. demonstrates how fast load changes, caused by turbine tests, place a grueling load on this pressure controller reducing station for makeup. In the words of the power plant engineer: "The control stability is good and the controller does the job well."

Leslie Pressure Pilot

Narrow Band Pressure Control *with Stability*

Wide band stability and narrow band proportional control are uniquely combined in the Leslie Control Pilot without need for extra mechanisms to correct for over-sensitivity.

While the pilot responds to small, *definite* pressure changes, it "sorts out" and "ignores" the small, spurious* disturbances common to most control systems. Since it does not follow nor magnify these disturbances, cycling and hunting are eliminated. It is ideal for systems with short lag factors.

*not directly related to process variables but resulting from pipeline friction and turbulence.

NO COSTLY EXTRAS

The "designed-in" stability and high capacity of Leslie Pressure Control Pilots also eliminates costly "extras" . . . there is no need for automatic reset, valve positioners or filter-type air sets. You get stable, reliable control *without* fussy adjustments and with *ordinary* plant air or water for the operating medium.

MORE INFORMATION

Ask your Leslie engineer to give you the complete story of the exclusive features that make Leslie Controllers ideal for straight pressure control problems. He's listed in your classified directory under "valves" or "regulators". Send for bulletin described at left.

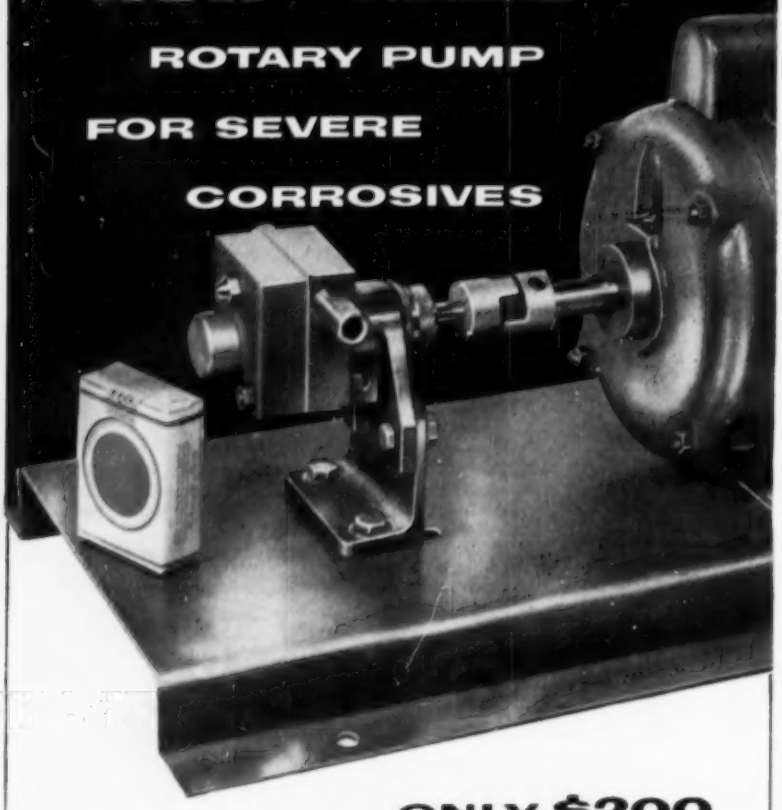
Send for Bulletin 5303 that gives complete technical data and typical application sketches for the Leslie Pressure Control Pilot.

TRADE LESLIE MARK

REGULATORS AND CONTROLLERS

LESLIE CO., 241 GRANT AVENUE, LYNDHURST, NEW JERSEY

NEW "MINILAB" ROTARY PUMP FOR SEVERE CORROSIVES



ONLY $200 FOR HASTELLOY C AND TEFLON CONSTRUCTION

For applications from 0 to 2 gpm, here is a self-priming pump designed for the most severe corrosive service in laboratory and pilot plant installations. Because of rugged construction, "Minilab" pumps can be used around-the-clock.

Internal, self-lubricating Teflon bearings eliminate all problems of product contamination. In addition, the pump can be steam and chemically sterilized. Yielding a linear flow, ideal for constant-flow metering, the unit is reversible and may be staged for higher pressures.

Send for complete specifications and pump curves.

Hastelloy — trademark of Union Carbide Corp. Teflon — trademark of E. I. duPont

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TITANIUM-ZIRCONIUM CONSOLIDATION

(Continued from page 58)

lory-Sharon Titanium Co. was already the nation's second largest producer of titanium mill products capable of melting one million pounds of titanium a month.

All Special-Metal Facilities of the Five Companies

Facilities of the new Mallory-Sharon Metals Corp. will consist of the complete Mallory-Sharon Titanium Co., entire ownership of Reactive Metals Inc. (joint company of National Distillers and Mallory-Sharon Titanium), and all the titanium and zirconium facilities of National Distillers, including the under-construction 10 million pound a year titanium plant, and the under-construction 2 million pound a year zirconium plant, both at Ashtabula, Ohio. In addition, the new company will have an exclusive royalty-free license to use National's new sodium reduction process for the production of titanium, zirconium and other metals.

National Distillers, Sharon and Mallory will each have a one-third equity in the new company, and National will hold, in addition, debentures in the new corporation totalling about $12.5 million.

Future Goal—Process Industries

With the recent adverse change in the titanium marketing picture brought about by the curtailed Air Force budget, Mallory-Sharon president James Roemer has admitted that his company "will be capable of producing more titanium in 1957 than we can sell."

But as production has gone up in the titanium industry, prices have dropped, applications in the process industries seem to be growing as lower prices make commercial use more attractive. The companies involved expect the commercial market to grow appreciably within the next ten years. As Roemer puts it, "While commercial use of titanium is not now substantial, we believe the future of titanium lies in this direction."

At present 95% of titanium production goes into military use, but production is expanding, competition from special steels is growing. The three companies see three major markets for titanium based on its properties: 1) process equipment in the chemical, petroleum and other industries where corrosion resistance to chemical or organic substances is of prime importance; 2) transportation

(Continued on page 62)

We're ready to take the wraps off...

a high capacity, high efficiency continuous solids discharge centrifuge

for dewatering and solids classification

and we'll prove it on your product...

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May we make arrangements for a run on your material in the Sharples Testing Laboratories . . . ?

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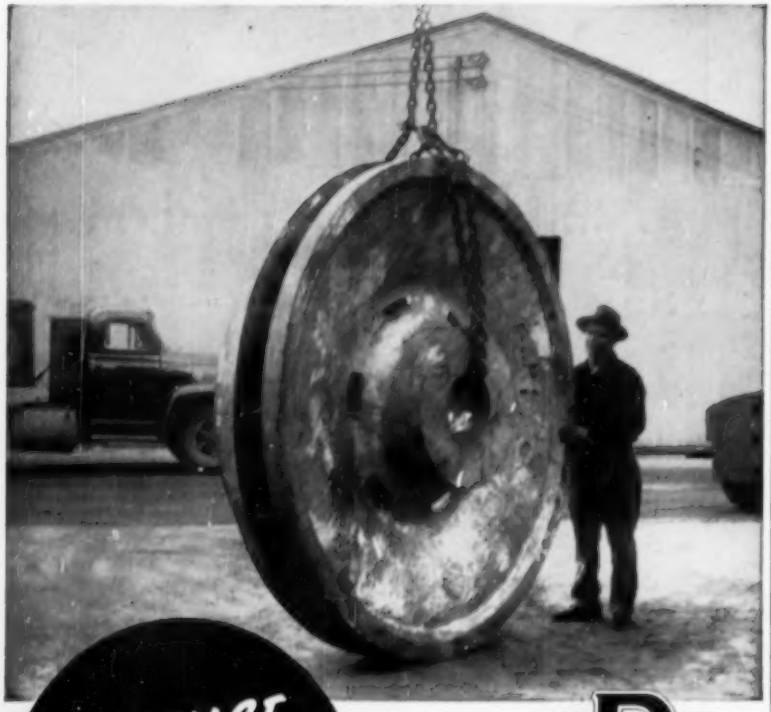

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DURALOY

It's a 7 ton 18-8 Casting designed to handle acidulous water

With our battery of large electric furnaces and our large modern well equipped molding department, castings of this size are quite common in our production schedule.

Yet, if you require it, we can produce castings as light as only a few ounces. In fact, with our shell molding department we can produce in quantity very small pieces of any high alloy analysis desired.

Experience? Well, our work with static high alloy castings goes back to 1922 and with centrifugal castings back to 1931. This long experience is your assurance of a sound casting correctly alloyed.

The DURALOY Company

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CHICAGO OFFICE: 332 South Michigan Avenue
DETROIT OFFICE: 23906 Woodward Avenue, Pleasant Ridge, Mich.

TITANIUM-ZIRCONIUM CONSOLIDATION

(*Continued from page 60*)

and other fields where savings in weight as related to strength are important; and 3) marine applications where resistance to sea water and sea air is vital.

Zirconium is in a similar position, cost of final product is major block to wider commercial application, but nuclear applications will scarcely form a large industry, chemical and petroleum processing equipment is the major hoped-for market.

While the use-potential of both metals, and of other "special metals" the new company may produce, is great, there are many commercial problems to be overcome. The three companies clearly feel that pooling their efforts will give them the greatest possible boost toward developing eventual wide-use of the new metals.

A contract in excess of $50,000,000 for design, engineering, and construction of a complete 43,000 b/d refinery has been awarded to Fluor Corp. by Commerce Oil Refining Corp. Located on Narragansett Bay, near Providence, R. I., the refinery will turn out more than 60 per cent of its production as 100 plus octane gasoline, remainder as distillate fuel oils and miscellaneous products. Target date for completion is early summer, 1959. □

100 tons per day of urea is capacity of new facilities planned by Spencer Chemical at their Henderson, Ky., Works. Completion date is set for mid-1958. □

Increased production of oil-treating compounds, corrosion inhibitors, other refinery chemicals is projected by Visco Products Co., Sugar Land, Texas. Design and construction of the additional facilities have been awarded to Fluor. □

One of the largest autoclaves ever built, this unit measures 96 ft. 3 in. long and 10 feet in diameter, was built by the Buflovak Equipment Division of Blaw-Knox. It is to be used for curing concrete blocks, will accommodate the entrance of forked trucks carrying the pallets of blocks.

LUMMUS

ENGINEERS AND CONSTRUCTORS FOR INDUSTRY

385 Madison Avenue New York 17, N. Y.

$11 MILLION ETHYLENE OXIDE-GLYCOL PLANT UNDER CONSTRUCTION FOR CALCASIEU CHEMICAL CORPORATION

Capacity to be 60,000,000 lbs./year of ethylene oxide or 8,000,000 gallons/year of glycol

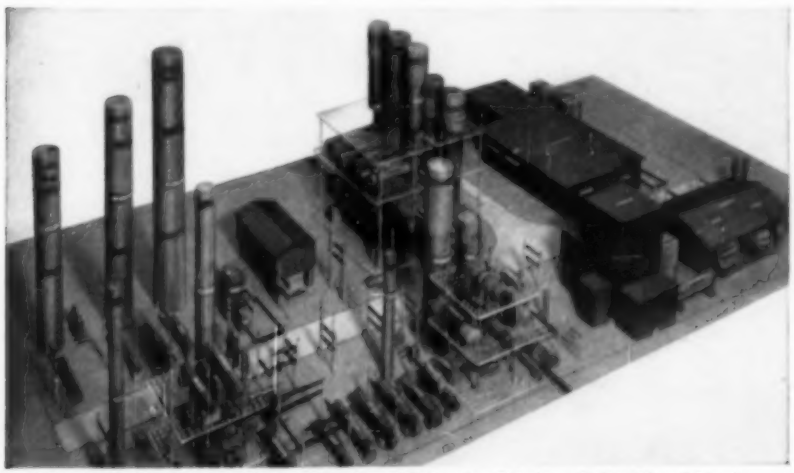
Utilizing the process developed by Shell Development Company, The Lummus Company has designed and engineered, and is now constructing an $11 million ethylene oxide and glycol plant for Calcasieu Chemical Corporation at Lake Charles, La.

When construction is completed by Lummus early in 1958, the facility will be staffed and operated by 50 employees of Petroleum Chemicals, Inc. P.C.I. will also supply ethylene raw material to the new plant, from an adjacent ethylene unit designed and now under construction by The Lummus Company.

The Shell Process, which offers the advantages of unusually high yields and virtual elimination of the waste disposal problems encountered in the Chlorohydrin Process, is conducted in two steps. The first step is direct catalytic oxidation of ethylene with oxygen in fixed bed reactors. Here ethylene oxide, valuable petrochemical intermediate, is produced for use by manufacturers of detergents and other surface active agents, plasticizers, solvents, textiles, drugs and many other petrochemical compounds.

The second step of the Shell Process calls for thermal hydration of ethylene oxide to ethylene glycol, essential to manufacturers of anti-freeze, explosives, plasticizers, fibers, resins, hydraulic fluids and many more chemical products.

This is the third ethylene oxide unit currently in construction by Lummus, based upon the Shell Process. For ethylene oxide and ethylene glycol, or for any type of chemical or petrochemical plant, Lummus' half century of world-wide experience is at your disposal.



Model used by Lummus in engineering of Calcasieu Ethylene Oxide-Glycol Plant.

THE LUMMUS COMPANY, 385 Madison Avenue, New York 17, N. Y. *Engineering and Sales Offices and Subsidiaries:* New York, Houston, Baton Rouge, Montreal, London, Paris, The Hague, Bombay. *Sales Offices:* Chicago, Caracas. *Engineering Development Center:* Newark, New Jersey.

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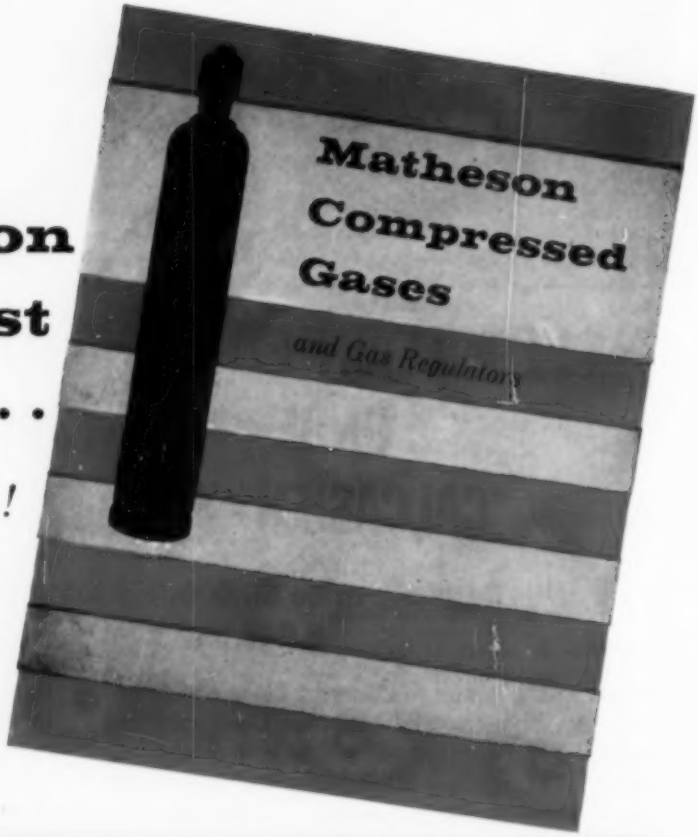

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Small needle valves in a greater variety of materials and outlet types

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Engineering Data • • •

MATERIALS

301 Properties of Silicone Grease. Brochure from Dow Corning describes properties and performance of Dow Corning 41, multi-purpose high-temperature lubricant.

302 Polymeric Plasticizer. Technical notes, details of physical, electrical, and migration properties of "Paraplex G-54," new plasticizer for use in vinyl chloride polymers intended for service under high-humidity conditions. Rohm & Haas Co.

303 New Dry Bearing Material. Chemloy, product of Crane Packing Co., requires no lubrication, is recommended for dry bearing services at temperatures to 500°F. and for use with solvents and practically all types of corrosives. Full information from manufacturer.

304 Water Treatment Booklet. Newly-developed blend of organic and inorganic chelating agents, "Ke-Tone" is said to inhibit scale formation and to remove deposits. Full details of treating method for refinery and chemical plant applications available from United Chemical Corp. of New Mexico.

305 Milk Chemicals Bulletin. Analyses and applications of milk proteins, edible caseins, peptones, lactose, etc. Bulletin from Sheffield Chemical, division of National Dairy Products Corp.

306 Rare Earth Data Sheets. Michigan Chemical Corp. offers series of data sheets with product data and application information on rare earth oxides and metal.

307 Cleaning Compound Booklet. E. F. Houghton & Co. offers 2-page booklet "Metal Cleaning Compounds" on alkaline, acid emulsion, and detergent cleaners. Also "Chemical Conversion Compounds," 24-page booklet on phosphating and blackening compounds.

308 Chlorothene Booklet. Complete technical information on Chlorothene (1,1,1-trichlorethane) available from Dow Chemical Co.

309 Water Evaporation Inhibitor. "Siponol EGH," a special combination of fatty alkanols, said to reduce evaporation by as much as 50% by forming monomolecular film bar-

(Continued on page 70)

HIGH-STRENGTH SILICONE RUBBER NOW COMMERCIALLY AVAILABLE

First use of new General Electric product expected to be in aircraft seals and gaskets, with chemical processing applications sure to follow.

The silicone products department of General Electric has added to the standard product line a new silicone rubber said to possess unusual physical strength, low moisture absorption, and good oil resistance. Typical physical properties of SE-555 are: 1,600 lb./sq.in. tensile strength; 650 to 850 per cent elongation; 200 to 250 lb./in. tear strength.

The new compound can be fabricated by all conventional methods of handling silicone rubber. It may be molded in thick section components or extruded with wall thicknesses of 10 mils and less. Complete technical information is available from the manufacturer. Circle Number 361 on Data Post Card.

An SE-555 silicone rubber extrusion, here stretched to several times its normal length, shows no signs of breaking or tearing.

ALL-PLASTIC GATE VALVE ON MARKET

Vanton Pump & Equipment Corp. offers what is claimed to be the first all-plastic gate valve specifically designed to meet the problems of conveying corrosive and abrasive liquids in lines that cannot be contaminated chemically. The new "Flex Plug" valve combines the straight-through flow, non-pressure drop characteristic of a gate valve and the throttling, flow-control feature of a globe valve. The combination is said to permit wide versatility of application.

Three stages of closure of new "Flex-Plug" gate valve. Left, fully open, no obstruction to flow, zero pressure drop. Center, half closed, showing conical cap which minimizes turbulence, allows throttling. Right, fully closed.

The valve is immediately available in 1 and 2 in. sizes with screwed ends. ½ to 4 in. sizes are expected to be on the market shortly. Materials of construction are rigid polyvinyl chloride and styrene-copolymer. Pressure rating is 200 pounds working pressure. The valve is said to perform equally well under vacuum service.

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(Continued on page 70)

CEP Data Service

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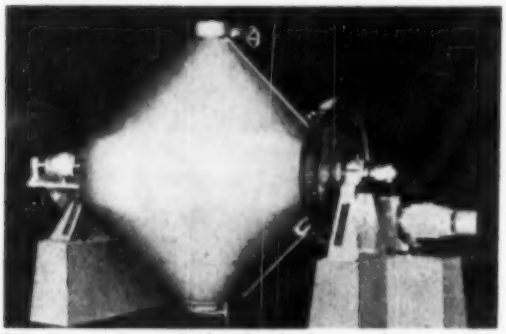
DEVELOPMENTS OF THE MONTH (*Cont.*)



363 Vacuum Dryer. Said to be the largest of its type ever built, a 9-ft. diam. Conaform Vacuum Dryer, built by the Canadian plant of Patterson Foundry and Machine Co., has been installed in the plant of Canadian Celanese, Ltd. at Drummondville, Quebec. The huge dryer is being used by Canadian Celanese as a powder dryer and blender. It has an operating capacity of 234 cu. ft., and is capable of handling materials up to 40 lb./cu.ft. According to the manufacturer, the Patterson Conaform dryer has been used in the vacuum drying of high-value chemicals, pharmaceuticals and technical products, temperature-sensitive materials, and crystalline particles. A bulletin with complete technical details is available from the maker. Circle number 363 on Data Post Card.

(Continued on page 67)

JUST A MOMENT is needed to learn how to use this insert. When looking through the front part of the magazine, pull the folder portion of the insert out to the right, and the numbers on the post card are convenient for circling.

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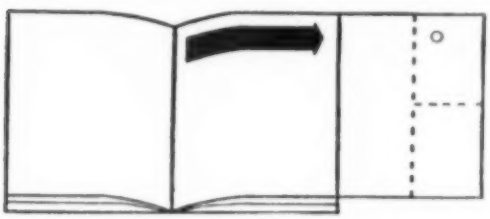

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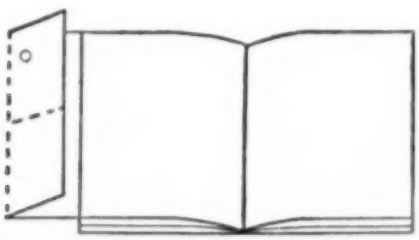

Numbers followed by letters are for checking your interest in the products, equipment, and services advertised in this issue, the number corresponding to the page on which the ad appears. Letters indicate position on the page: L, left; R, right; T, top; B, bottom. A indicates a full page; IFC, IBC, and OBC are cover advertisements. **Numbers in the 300-series** bring you new engineering data in the chemical engineering field.

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DEVELOPMENTS OF THE MONTH (Cont.)

364 Data on Non-Woven Fabrics. A 15-page report from DuPont summarizes the latest information in this growing field. Methods of production are described, including an estimate of the equipment and the investment needed. Typical physical properties and characteristics of non-woven fabrics are presented in tabular form. The report concludes with a survey of present and potential markets for non-woven fabrics. (For a consideration of one field of industrial application, see article "Non-woven Filter Media" by Arthur C. Wrotnowski, *CEP*, July, 1957, p. 313). Further information will be supplied by DuPont. Circle number 364 on Data Post Card.

365 Side-Entering Agitators. Industrial Process Engineers offer an illustrated brochure covering their line of guaranteed-performance side-entering agitators. Included are mechanical design details, a standard sizes and dimensions table, application data.

Stressed in the brochure is Industrial Process Engineers' guaranteed-performance policy. Number and size of units, how they should be positioned, etc., are derived from the basic process data supplied by the client. Mixing results for the equipment supplied are guaranteed for any process requirement.

Design features are:

- Rugged, tapered roller bearings instead of ball bearings.
- Readily - accessible stuffing box, easy to repack without emptying or depressuring the vessel.
- Separate flange-mounted motor and spiral bevel gear drive.
- Reduced overall length, requiring less space.

For complete details, circle number 365 on Data Post Card.

366 Alloy and Stainless Steel Catalog. Electric Steel Foundry Co. offers 102-page catalog of alloy and stainless steels for the process and manufacturing industries. Included are comprehensive corrosion resistance data, chemical composition, representative mechanical properties of corrosion-resistant, heat-resistant, impact and abrasion-resistant alloy steels. Complete specifications are given for piping, flanges, and fittings, as well as for tubing in various wall thicknesses. To obtain a copy of the catalog, circle number 366 on Data Post Card.

(Continued on page 70)

PRODUCTS ADVERTISED IN THIS ISSUE

IFC Heat Exchangers. In stainless, aluminum, nickel, copper, Monel, Inconel, Hastelloy, many other alloys. Custom-built to any specified design. Technical data from Vulcan-Cincinnati, Inc.

3R Automatic Bulk Feeders. Draver feeders, product of B. F. Gump Co., now available with automatic timing controls to prevent overloading of grinders, sifters, mixers, other production machines.

4A Entrainment Separator Bulletin. Describes Yorkmesh Demisters, designed to improve performance of vacuum towers, distillation equipment, gas absorbers, scrubbers, evaporators, steam drums. Otto H. York Co.

7A Nuclear Engineering Services. New $50,000,000 reactor feed-material plant, to be operated by Mallinckrodt Chemical Works for A.E.C., is being designed and engineered by Blaw-Knox.

8A-9A Asbestos Insulation Booklet. Brochure from Johns-Manville describes properties of "Thermobestos" insulation, specially developed for outdoor process industry applications.

10L Filtration Catalog. Specifications and other technical data on line of filter presses made by D. R. Sperry & Co.

11A Stainless Steel Equipment Bulletin. Brochure "Making the Most of Stainless Steels in the Chemical Process Industries" offered by Crucible Steel Co. of America.

12A Leakproof Pumps. Pump and motor combined in single leakproof unit, no shaft sealing device required. For temperatures to 1,000°F. and pressures to 5,000 lb./sq.in. Chempump Corp.

13A Turbo-Film Processor. For high concentration of heat-sensitive solutions without impairment of essential values. Full information from Rodney Hunt Machine Co.

15A Heat Exchanger Design Bulletin. 28 pages of technical data on standard and custom-built heat exchangers. Pfaudler Co.

16L Corrosion-Resistant Lining Material. Kel-F Laminate is extremely resistant to acids, alkalies, oxidants, and solvents at temperatures to 350°F. Technical data from United States Gasket Co.

17A Jobs in Nuclear Engineering. Careers in the nuclear power industry open at Bettis Atomic Power Division, Westinghouse Electric Corp.

18A Closed-Circuit Air Separator. Bulletin from Sturtevant Mill Co. gives technical data on separation systems designed to increase efficiency of grinding equipment.

23A Dust Collector Bulletin. Technical details, performance data on the Mikro-Pulsaire, made by Pulverizing Machinery Division, Metals Disintegrating Co.

24A-25A Chemical Engineering Catalog. Gives the facts about products and services from over 500 companies. Companion catalog gives detailed chemical and raw materials information from over 130 companies. Reinhold Publishing Corp.

26A Molecular Sieve Adsorbents. Technical data and performance characteristics information available from the Linde Co.

27A Continuous Heat Transfer Equipment. Votator processing apparatus, made by Girdler, is used by hundreds of leading food and chemical companies.

28L Bulletin on Corrosion. Describes complete line of corrosion-proof cements, linings, coatings, and rigid plastics. Atlas Mineral Products Co.

29A Chemical Processing Furnaces. Petrochem Isoflow furnaces are used throughout the petroleum, chemical, and allied industries. Designs for any duty, temperature, or efficiency. Details from Petro-Chem Development Corp.

30L Wire Cloth Catalog. 90-page catalog from Cambridge Wire Cloth Co. Includes description of fabrication facilities and useful metallurgical data.

31A Contract Engineering Services. The "Key Man" principle is an essential factor in every engineering contract with Badger Manufacturing Co. You always deal with a Badger principal.

32A-33A Pressure Controllers. Bulletin from Fisher Governor Co. gives complete details on the Wizard II, designed for closer control in complex processing industries.

34L Glassed Pump Bulletin. Complete information on the new Goulds-Pfaudler line of glassed pumps. Capacities to 700 gal./min., heads to 140 ft. Goulds Pumps, Inc.

35A Mixers. Philadelphia Model PTS mixers are designed for top stuffing box performance with minimum maintenance. Details from Philadelphia Gear Works, Inc.

36L Pump Catalog. Ingersoll-Rand Motorpumps are available from ⅛ through 75 hp., capacities to 2,800 gal./min., heads to 650 ft.

37A Lithium Compounds as Polymerization Catalysts. Information from Lithium Corp. of America on use of lithium metal and certain compounds as polymerization catalysts in manufacture of plastics, polymers, and resins.

39A Impervious Graphite Heat Exchangers. Catalog from National Carbon Co. gives technical data on complete line of "Karbate" shell and tube exchangers.

40A-41A Flow Transmitters. Bulletin from Foxboro Co. describes the d/p Cell Transmitter. No zero drift, positive overrange protection, high sustained accuracy.

42A Pump Data. Aldrich Pump Co. offers full technical details and specifications of their line of process pumps.

43A-44A Chemical Exposition. The 26th Exposition of Chemical Industries will be held in New York Coliseum, December 2-6, 1957.

45A Mixers. For process jobs where complete dispersion is paramount and where consistency, uniformity, and quality count. Read Standard, division of Capitol Products Corp.

46A Process Equipment Fabrication. Heat exchangers, steel and alloy plate fabrication, containers and pressure vessels for gases, liquids, and solids. Bulletin from Downingtown Iron Works.

48A Pump Selection Data. Complete technical data and consulting services available from Fairbanks, Morse & Co.

460A Tower Distributor Bulletin. 24-page bulletin describes complete line of support plates and distributors. U.S. Stoneware.

49A Expansion Joints. Corruflex expansion joints are packless, require no maintenance. Sizes 3 to 4 in. For temperatures to 1600°F. and pressures to 300 lb./sq.in. Adsco Division, Yuba Consolidated Industries, Inc.

51A Clarifiers. The Westfalia KG clarifier, made by Centrico, Inc. features an extra-large six-chamber bowl. Bulletin.

> ○ **CHECK** *your Data Service requests on the handy postcard on page 66 to*
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> ▶ **GET** *up-to-the-minute catalogs, data sheets and bulletins on new chemical products, processes and equipment.*

53A Sulfur. Sulfur is an essential ingredient of "Thiokol" synthetic rubber, an organic polysulfide elastomer used in solid propellents for missiles. Texas Gulf Sulphur Co.

54L Thermo-Compressors. Designed for economy and efficiency in evaporation processes. Technical details from the Elliott Co.

55A Nitrogen Gas Generators. A complete packaged unit which produces high purity nitrogen and, when required, CO_2 from the same unit simultaneously. Data from Gas Atmospheres, Inc.

56L Flexible Pipe Connectors. Custom machined or molded to meet any requirement from one convolution up. In any shape or size, open or closed end. Pressures to 75 lb./sq.in. Full information from Crane Packing Co.

57A Plastic Materials Bulletin and Corrosion Guide. Sheet linings, all-plastic structures, acid-proof mortars, coatings. Electro Chemical Engineering & Manufacturing Co.

(Continued on page 72)

PRODUCTS ADVERTISED IN THIS ISSUE

IFC Heat Exchangers. In stainless, aluminum, nickel, copper, Monel, Inconel, Hastelloy, many other alloys. Custom-built to any specified design. Technical data from Vulcan-Cincinnati, Inc.

3R Automatic Bulk Feeders. Draver feeders, product of B. F. Gump Co., now available with automatic timing controls to prevent overloading of grinders, sifters, mixers, other production machines.

4A Entrainment Separator Bulletin. Describes Yorkmesh Demisters, designed to improve performance of vacuum towers, distillation equipment, gas absorbers, scrubbers, evaporators, steam drums. Otto H. York Co.

7A Nuclear Engineering Services. New $50,000,000 reactor feed-material plant, to be operated by Mallinckrodt Chemical Works for A.E.C., is being designed and engineered by Blaw-Knox.

8A-9A Asbestos Insulation Booklet. Brochure from Johns-Manville describes properties of "Thermobestos" insulation, specially developed for outdoor process industry applications.

10L Filtration Catalog. Specifications and other technical data on line of filter presses made by D. R. Sperry & Co.

11A Stainless Steel Equipment Bulletin. Brochure "Making the Most of Stainless Steels in the Chemical Process Industries" offered by Crucible Steel Co. of America.

12A Leakproof Pumps. Pump and motor combined in single leakproof unit, no shaft sealing device required. For temperatures to 1,000°F. and pressures to 5,000 lb./sq.in. Chempump Corp.

13A Turba-Film Processor. For high concentration of heat-sensitive solutions without impairment of essential values. Full information from Rodney Hunt Machine Co.

15A Heat Exchanger Design Bulletin. 28 pages of technical data on standard and custom-built heat exchangers. Pfaudler Co.

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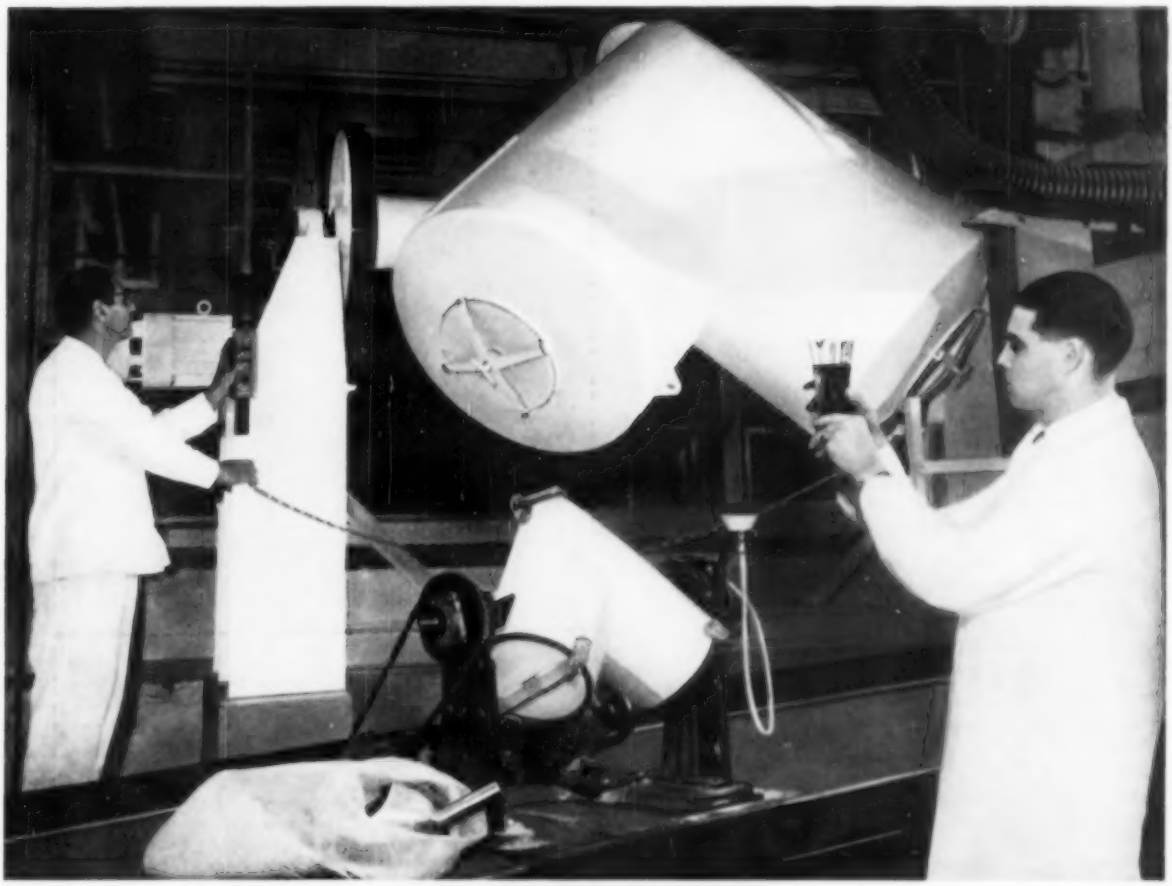
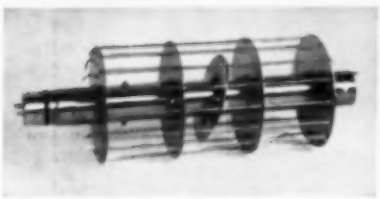
57A Plastic Materials Bulletin and Corrosion Guide. Sheet linings, all-plastic structures, acid-proof mortars, coatings. Electro Chemical Engineering & Manufacturing Co.

(Continued on page 72)

Now! For the first time

intimately blend any liquid, regardless of viscosity, into dry solids–in one fast step–even up to 40% liquid volume by weight





VERSATILE. This wire cage assembly gives you three blenders in one. With it you can blend liquids into solids, or obtain dry intensive mixing action. Remove it and get gentle blending.

TYPICAL EXAMPLE. Bar breaks down agglomerates in material at left and prevents new agglomeration as liquid is added. Note uniform consistency in finished blend at right.

ABSOLUTE UNIFORMITY. Laboratory smear test reveals streaks where standard blending methods are used (left). With P-K's exclusive design, complete blending is assured (right).

These results can be proved in your own lab with a P-K Laboratory Model Liquid-Solids* Blender. 8 or 16 qt. capacity available from stock for instant delivery.

Scale-ups from lab tests are equalled or bettered in P-K production models with capacities from 1 to 50 cubic feet. This is a completely new concept in liquid-solids blending –exclusive with P-K.

Write now for Bulletins 15A on lab units, 7-15-A on production units of P-K liquid-solids blenders. The Patterson-Kelley Co., Inc., 710 Hanson Street, East Stroudsburg, Pa.

Patterson Kelley

Chemical and Process Division

P-K Twin Shell Blenders* • Heat Exchangers

Packaged Pilot Plants • P-K Lever-Lock Doors*

*Patents pending

MATERIALS (*Cont.*)

rier on surface. Samples for field tests available without charge from American Alcolac Corp.

310 Dichloroethyl Formal. Thiokol Chemical Corp. offers technical data on dichloroethyl formal, used in production of synthetic rubber, dyestuffs, pharmaceuticals, plasticizers, and resins as a chemical intermediate.

311 Titanium Buyers Guide. Technical data and price lists on wide variety of titanium and titanium alloy products offered by Titanium Metals Corp. of America.

312 High-Temperature Uses of Carbon and Graphite. 8-page bulletin from Speer Carbon Co. gives charts showing material grades, size ranges, physical and chemical properties for each grade and type.

314 "Boral" Technology. Bulletin from Brooks & Perkins, Inc. describes neutron shielding properties of "Boral," a mixture of boron carbide and aluminum rolled in ⅛ or ¼ in. thick sheets.

315 Chlorinated Paraffin Data. 15-page technical bulletin "Evaluation of Chlorinated Paraffin as a Secondary Plasticizer for Polyvinyl Chloride" offered by Chlorinated Products Division, Diamond Alkali Co.

316 Petroleum Sulfonates. New series of petroleum sulfonates, "Duonates," made by L. Sonneborn Sons, Inc., for emulsification and dispersion of liquids, dispersion and wetting of solids and liquid-solid systems. Samples available.

317 Linear Polyethylene. "Wynene," linear polyethylene product of the National Plastic Products Co., said to be ideally adaptable for vacuum forming.

318 Carbon Steel Mechanical Tubing. 8-page folder from Tubular Products Division, Babcock & Wilcox Co. lists mechanical properties and size tolerances of their electric-resistance-welded mechanical tubing.

319 Methallyl Alcohol Bulletin. Comprehensive technical bulletin from Organic Chemicals Division, Food Machinery and Chemical Corp., describes properties of methallyl alcohol (2-methyl-2-propene-1-01). Development quantities available.

320 Asbestos Paper Brochure. Includes chart showing thickness, weight, tensile strength, tear strength, and bursting strength of all Commercial and Fibroid asbestos papers made by Johns-Manville.

321 Corrosion-Resistant Materials. Catalog from Ralph V. Rulon, Inc. covers mastics for floors, acidproof brick, complete line of chemically-resistant mortars, impervious liners, and protective coatings.

322 New Antifoam Agent. "Antifoam TBX," product of Hodag Chemical Corp., said to be effective for systems based on starches and dextrines; natural proteins; and synthetics—latexes, methyl cellulose, polyvinyl alcohol, and carboxymethylcellulose. Complete technical information from Hodag Chemical Corp.

323 Polymeric Plasticizer Brochure. Summarizes investigations carried out by Eastman Chemical Products, Inc. on effectiveness of its polymeric plasticizer NP-10 in vinyl plastisol formulations.

324 Hydrogen Peroxide Booklet. Up-to-date review and bibliography of the application of hydrogen peroxide for epoxidation and hydroxylation is offered by Solvay Process Division, Allied Chemical & Dye.

325 Dimethyl Sulfide Data Sheet. Purity, solubility, physical constants, chemical reactions of dimethyl sulfide described in folder from Chemical Products Division, Crown Zellerbach Corp. Samples also available.

EQUIPMENT

326 Compressed Asbestos Fiber Jointings. Booklet from Richard Klinger, Inc. gives properties and recommended grades of Klinger jointings for various chemicals.

DEVELOPMENTS OF THE MONTH (*Cont.*)

367 Electric Bulk Materials Distributor. Hayes & Stolz Industrial Manufacturing Co. offers what is said to be the first bulk materials distributor with a positive electric control panel. The distributor is recommended for any free-flowing material. Correct setting is assured by merely flicking a numbered switch; settings are indicated by lights on the control panel. Standard units are available with from five to twenty openings, more openings can be specified if desired. Pipe sizes run from 6 to 10 in. Sizes from 12 in. up can be supplied on request. Extra monitor panels for remote control can be furnished. The unit itself is adaptable for mounting on elevators, collectors, under bins, or on sifters, mixers, screw conveyors, and belt conveyors.

Complete technical details are available from the manufacturer. Circle number 367 on Data Post Card.

(Continued on page 72)

327 Dust Collection Equipment. Multiple cyclone collectors, fly ash arrestors, liquid scrubbers, induced draft fans, smoke eliminators, special duct work. Bulletins from Fly Ash Arrestor Corp.

328 Digital Voltmeter Data Booklet. 28-page booklet describes line of digital voltmeters, digital ohmmeters, a.c.-d.c. converters, and complete data logging systems. Many charts and diagrams. Non-Linear Systems, Inc.

329 Process Equipment Fabrication. Puget Sound Fabricators, Inc. offer brochure describing their facilities for the fabrication of equipment in steel plate and alloy up to 1 in. thickness.

330 Linear Planimeter. Model 601 Linear Planimeter, product of Librascope, Inc. is a small, desk-size precision analog computer which can be used for integrating data from chart recordings of all process flow variables. Literature.

331 High Vacuum Valve Catalog. 32-page engineering manual from NRC Equipment Corp. describes comprehensive line of high vacuum valves in wide range of styles and materials of construction.

332 Chemical Processing Equipment. Stainless steel, corrosion, and heat-resistant equipment, radiation shielding. Brochure from O. G. Kelley & Co. also describes newly-developed process for applying homogeneous lead bondings.

333 Pressure Gauge Catalog. Types of systems, adjustments, applications, dimensional drawings, specifications of line of "Helicoid" gauges contained in catalog from Helicoid Gage Division, American Chain & Cable Co.

334 Valve Catalog Sheet. Describes spring-loaded dual purpose relief and back pressure valve for both condensing and non-condensing systems. Atlas Valve Co.

335 End Suction Centrifugal Pumps. Close-coupled end suction general purpose pumps in horizontal, close-coupled horizontal, pedestal mounted, flange mounted vertical, and base mounted vertical units. Details from Aurora Pump Division, New York Air Brake Co.

336 Mechanical B.t.u. Meter. The Pollux B.t.u. Integrating Meter, made by Air Conditioning Equipment Corp., is a completely mechanical instrument that measures heat in thermal units and liquid flow in gallons with high precision. Bulletin available.

337 Process Moisture Monitor. Data sheet from Consolidated Electrodynamics Corp. describes their new Type 26-310 process moisture monitor which is designed for the accurate measurement, recording, and control of low moisture levels.

338 Gear Motor Bulletin. U. S. Electrical Motors, Inc. offer brochure on their line of Type GW right-angle "Synchrogear" motors. Speeds 13.5 to 155 rev./min., gear ratios up to 87:1, ¼ to 3 hp.

339 Dry Processing Equipment Catalog. Use of air separators in closed-circuit grinding. "Micronizer" fluid energy mills grind-

(Continued on page 72)

PUMP HOUSING is made precisely and accurately from REFRAX® silicon-nitride-bonded silicon carbide. It is used in handling chemical abrasive slurries where corrosion resistance is most important.

Refractories . . . to surpass **metals**

What material combines *all* the following properties? Corrosion resistance so that it is not wet by molten aluminum, and resists attack by most acids; abrasion resistance that prevents wear by both high velocity particles and sliding heavy masses; the ability to withstand temperatures to 3000° F; hot strength so high that at 2450° F its modulus of rupture is 5600 psi?

What material *combines* all these properties? Obviously not a metal, not even a cermet. It is one of Carborundum's special refractories — REFRAX® silicon-nitride-bonded silicon carbide. This material can be precisely formed to tolerances of ±0.005 in./in. with external and internal threads. Finish resembles that of a cast iron part.

Your high temperature problem, no matter how complex it may be, can almost certainly be solved with one of the scores of super refractories by Carborundum. For assistance, write for these three booklets:

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Please send me:

- ☐ Current issue of Refractories magazine on REFRAX®
- ☐ Reprint of article in Product Engineering, Feb. '57 entitled "Nitride bonded silicon carbide bridges gap between metals and ceramics",
- ☐ Bulletin on REFRAX®

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Company _____

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City _____ Zone _____ State _____

EQUIPMENT (*Cont.*)

ing, and rotary batch blenders described in 8-page bulletin from Sturtevant Mill Co.

340 Data on Agitating Nozzles. Bulletin from Pfaudler Co. describes characteristics and capacities of agitating nozzles used to produce a turbulent flow of the heating or cooling medium in a tank jacket.

341 General Purpose Centrifugal Pumps. In six basic sizes, capacities from 100 to 3,500 gal./min., pressures to 450 lb./sq.in., heads to 1,100 ft., temperatures to 300° F. 16-page bulletin from Ingersoll-Rand.

342 Viscosimeter Catalog. Describes the "Viscorator," made by Fischer & Porter Co., an auto-sampling device which continuously measures and records temperature and temperature-compensated viscosity of liquids flowing in pipes.

343 Polyethylene Laboratory Ware Catalog. Descriptions and prices of complete selection of laboratory apparatus in polyethylene. Harshaw Chemical Co.

344 Self-Priming Rotary Pump. Low-capacity, self-priming rotary pump in Hastelloy CR is available from Eco Engineering Co. Capacities to 2 gal. min., pressures to 50 lb./sq.in., temperature range from —200° F. to +300° F. Technical data.

345 Static Seals. 18-page catalog from Franklin C. Wolfe Co. lists all their standard types of static seals. Free design service also available.

346 PVC Pipe, Fittings, Valves. Physical and chemical properties, application table, installation information for several types of unplasticized polyvinyl chloride pipe, fittings, and valves. Alpha Plastics, Inc.

347 Pneumatic Conveying Systems. Detailed technical information, system diagrams of typical installations of the "Air-stream" conveying system. Bulletin from Dracco Corp.

348 Processing Equipment Bulletin. Bulletin from Bauer Bros. Co. covers line of pulverizing, fiberizing, granulating, and blending equipment.

349 Two-stage Vacuum Pumps. For both wet and dry systems. Rated capacities from 28 to 880 cu. ft./min. Technical data from Beach-Russ Co.

350 Low-Cost Rotameter. Bulletin from Brooks Rotameter Co. gives complete specifications, capacity, and dimension data on a new low-cost "Sho-Rate" rotameter with 150 mm. scale length.

351 Corrosion-Resistant Glassed Pump. Bulletin from Goulds Pumps, Inc. describes new glassed centrifugal pump, designed in collaboration with the Pfaudler Co. Heads up to 140 ft., four sizes for capacities up to 700 gal./min.

352 Relief and Back Pressure Valves. Complete specifications including capacities, dimensions, and materials of constructions for four standard sizes. Bulletin from Milton Roy Co.

353 PVC Pipe and Fittings. Bulletin and price list from Luzerne Rubber Co. covers their complete line of polyvinyl chloride pipe, fittings, and valves.

354 Deep Well Turbine Pumps. Designed for application in wells up to 750 ft. deep. Oil or water lubricated. Brochure describes design and construction features. A&C Pump Co.

355 Packless Rotary Pressure Joints. Three bulletins from Johnson Corp. cover their complete line of self-adjusting, self-lubricating, and self-supporting rotary pressure joints, including information on new quick release nipple.

356 Instantaneous Ozone Meter. A precision instrument designed to determine accurately the concentration of ozone in air or oxygen. Concentration read directly from the scale in milligrams per liter. Technical literature from Welsbach Corp.

357 Bin Level Indicator. The "Roto-Bin-Dicator," product of the Bin-Dicator Co., has been improved to permit use under severe or rugged operating conditions. Bulletin and price list available from manufacturer.

358 Tubular Products. Wolverine Tube offers new catalog "Wolverine Serves the Refrigeration Industry."

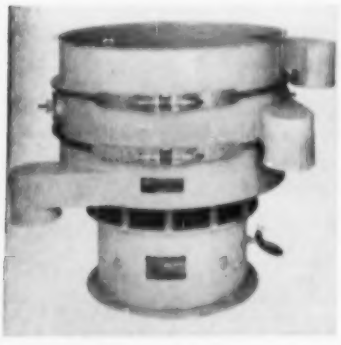
SERVICES

359 Aluminum Coating Process. The "Alumicoat" process metallurgically bonds aluminum to steel, checks corrosion and heat oxidation. Brochure from Arthur Tickle Engineering Works, Inc.

360 Radiation Products and Services. Nuclear Systems, division of the Budd Co., has a completely-staffed and equipped radiation service and research facility.

DEVELOPMENTS OF THE MONTH (*Cont.*)

368 Vibrating Screen Separators. A new line of 30 in. diam. vibrating screen separators in 1, 2, and 3-deck models is offered by Southwestern Engineering Co. The units are constructed of carbon steel or Type 316 stainless steel and employ a totally-enclosed 60 cycle, 3 phase, 1,200 rev./min., ½ hp., 220/440 v. motor. Explosion-proof motors, 50 cycle, and 550 v. motors are also available. These screens are said to be adapted for the screening of over 200 different materials—wet or dry, coarse or fine, hot or cold—as well as in the separation of solids from liquid. Two to four fractions can be obtained with a 1, 2, or 3-deck separator.



For further details, circle number 368 on Data Post Card.

(Continued on page 74)

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PRODUCTS ADVERTISED IN THIS ISSUE (*Cont.*)

59A Pressure Control Pilot. Leslie Co. offers bulletin with complete technical data and typical application sketches on their line of pressure control pilots.

60L Small Corrosion-Resistant Pumps. Complete specifications and pump curves from Eco Engineering Co. describe their line of small pumps for laboratory and pilot plant installations.

61A Continuous Solids Discharge Centrifuge. Sharples Corp. will make arrangements for a run on your material using their newly-developed Series P-3000 Super-D-Canter.

62L High Alloy Castings. Duraloy Co.'s experience with static high alloy castings goes back to 1922, and with centrifugal castings back to 1931.

63A Ethylene Oxide and Ethylene Glycol Plants. $11,000,000 ethylene oxide-ethylene glycol plant designed, engineered, and under construction by the Lummus Co. is third of its type.

64A Compressed Gas Price List. Prices and data on 76 compressed gases and mixtures in 5 cylinder sizes. Matheson Co., Inc.

69A Liquid-Solids Blenders. Bulletin from Patterson-Kelley Co. describes production units of P-K liquid-solids blenders. Capacities from 1 to 50 cu.ft.

(Continued on page 74)

STAINLESS STEEL

produced the way *you* want it by Carlson

Only at Carlson can you buy so many grades of stainless steel in the wide variety of shapes and sizes illustrated here. We regularly process such complete bill-of-material orders. Trained Carlson men, with years of experience and practical knowledge, are determined to give you the best and most efficient service possible.

When you need stainless plate . . . Carlson gives you what you want when you want it!

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STAINLESS STEEL PLATE . . . rolled to almost any size or thickness, 3/16" and heavier, to meet your individual needs—whether rectangles, circles or special patterns. Substantial tonnage in Types 302, 304, 304-L, 309, 309-S, 310, 316, 316-L, 317, 317-L, 321, 347, 348, 405, 410, 430 and 502-½% Mo. is available for prompt delivery. In addition, two precipitation-hardening grades, Types 17-4 PH* and 17-7 PH* are now in production.

STAINLESS STEEL HEADS . . . in Types 304, 304-L, 316 and 316-L are available from stock in ASME and Standard specifications (10" to 72" diameter). A large assortment of dies is available for pressing other types of heads and special sizes can be spun where practical.

STAINLESS STEEL FORGINGS and SPECIAL PATTERNS . . . including tube sheets, flanges, circles, rings, sketch plates and other specialties can be produced to specification on our versatile equipment.

Also STAINLESS STEEL BARS AND SHEETS (No. 1 Finish).

*Trade mark of ARMCO STEEL CORPORATION

PLATES • PLATE PRODUCTS • HEADS • RINGS • CIRCLES • FLANGES • FORGINGS • BARS and SHEETS (No. 1 Finish)

PRODUCTS ADVERTISED IN THIS ISSUE (*Cont.*)

71A Super Refractory Bulletin. Information from Carborundum Co. on properties of Refrax (silicon-nitride-bonded silicon carbide).

73A Stainless Steel Products. Plate, heads, forgings, bars, sheets, and special patterns. Technical data from G. O. Carlson, Inc.

75A Diatomaceous Filteraids. Bulletin from Dicalite Dept., Great Lakes Carbon Corp. discusses practical applications of Dicalite filteraids.

77A Process Equipment Fabrication. In cast iron, ductile iron, fabricated steel, stainless steel, and alloys to meet ASME code requirements. Bethlehem Foundry & Machine Co.

78A-79A Mineral Filler. Celite processed diatomite filler is claimed to have as much as 10 times greater bulking action than any other mineral filler. Details from Johns-Manville.

80TL Continuous Feeders. Bulletin from Wallace & Tiernan, Inc. gives technical details of their line of Merchen Scale Feeders.

80BL Absolute Pressure Indicator. Ranges from 0-50 mm. to 0-800 mm. absolute. Wallace & Tiernan, Inc.

81A Engineering and Construction Services. A new 10,000 b/d Platformer-Uniformer was recently completed for Wilshire Oil Co. by Southwestern Engineering Co. in 13 months.

82L Free Coating Thickness Gauge. Allows measurement of wet film thickness during application, determination of final dry thickness. Carboline Co.

83A Industrial Jet Equipment. Chillvactors, steam-jet evactors, Aqua-vactors, fume scrubbers, special jet apparatus. Croll-Reynolds Co.

84L Porous Stainless Steel Filters. Poro-Klean filters can withstand differential pressures of more than 3,500 lb./sq.in. and can handle viscous liquids at high flow rates. Bulletin from Cuno Engineering Corp.

85A Heat Exchange Equipment. Expertly designed for required operating pressures and temperatures and for maximum heat transfer. Yuba Consolidated Industries, Inc.

87A Oxygen Generating Equipment. Built, operated and maintained at your plant site by Air Products, Inc. No capital investment on part of user.

88L Laboratory Stirrers. Complete data on line of laboratory stirrers offered by Ace Glass, Inc.

89A Pressure Filters. Eimco Corp. offers consulting services and technical data on rotary pressure filters.

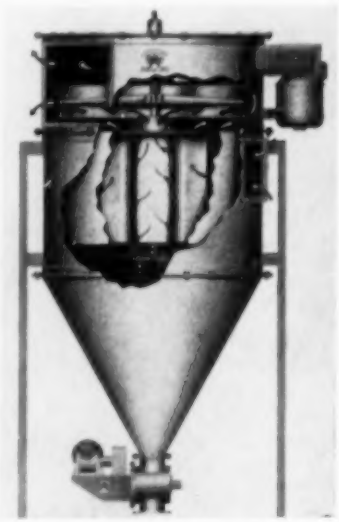
90L PVC Plastic Pipe Brochure. Detailed brochure from Kraloy Plastic Pipe Co. describes line of PVC plastic pipe and PVC high impact plastic pipe and tubing.

90R Water Demineralization Equipment. Catalogs from Barnstead Still & Demineralizer Co. describes water stills, mixed-bed, two-bed, and four-bed demineralizers, and micron filters.

91R Viscometer Application Data Sheet. The Brookfield Viscometran is now being used successfully for end point determination and continuous "in-process" viscosity recording. Brookfield Engineering Laboratories, Inc.

DEVELOPMENTS OF THE MONTH (*Cont.*)

369 Low-Cost Filter Unit. A new unit, said to combine the operating features of a cyclonic dust separator with the high efficiency of a dust filter, is offered by the Day Co. Efficiencies are stated to range up to 99.99+%. The unit employs the "Hersey" principle of high-velocity reverse air cleaning, differing from standard practice in that the dust is deposited on the outside of the filter sleeves. The filter sleeves are surrounded by an inner liner so that the dust-laden air travels in a cyclonic path separating the heavy dust particles before the air carrying the "fines"



enters the filter chamber. The unit is designed for automatic continuous operation without shut-down for rapping or cleaning. Product discharge is handled automatically and continuously by means of a rotary valve. All moving parts are located on the clean air side to assure long life for the mechanical assembly.

Detailed information and specifications are available from the manufacturer. Circle number 369 on Data Post Card.

(Continued on page 76)

92TL Heat Exchange and Process Equipment. Condensers, evaporators, kettles, mixers, agitators, reactors, pressure vessels, heat exchangers. Manning & Lewis Engineering Co.

92BL Mechanical Sealing Catalog. A valuable reference book for maintenance engineers and original equipment designers. Durametallic Corp.

93A-94A Product Bulletins. U.S. Industrial Chemicals Co. offers bulletins on sodium dispersions, proteins and amino acids in animal feeds, new adhesive, other new products and developments.

95A Controlled-Volume Chemical Pump. Bulletin from Lapp Insulator Co. gives typical applications, flow charts, description and specification of models of various capacities and constructions.

96L Air-Cooled Condenser. Using air as cooling medium, the Niagara Aero Vapor Condenser is said to produce a higher vacuum with more economy of power and steam. Bulletin from Niagara Blower Co.

97A Ultrasonic Degreaser. Ultrasonic cleaning equipment, made by Industrial and Scientific Products Division, Curtiss-Wright Corp., can be custom-suited to many types of industrial production. Details from manufacturer.

99A Compacting Process. Bulletin from Allis-Chalmers describes their compacting process which can result in 70 to 80% recovery of salable product.

100L Spray Nozzle Catalog. Details on nozzle applications, sizes, capacities, spray patterns, and metals. Easy-to-use selection tables. Binks Manufacturing Co.

100R Nickel Alloy Equipment Fabrication. Design, development, fabrication of specialized corrosion-resistant alloy equipment. Misco Fabricators, Inc.

101L Polyethylene Atmosphere Scrubbers. Engineered and built to your specifications. Detailed literature from American Agile Corp.

101R Chlorine Control Handbook. W. A. Taylor and Co. offers handbook "Modern pH and Chlorine Control." Illustrates and describes full Taylor line of equipment.

102B Screw Engines. For oil-free handling of air and many other gases. Flow rates from 350 to 15,000 cu.ft./min. Pressures to 155 lb./sq.in.abs. Foram Corp. (representatives of Gutehoffnungshütte, Germany).

103A Fabricated Graphite Products. Great Lakes Carbon Corp. specializes in the fabrication of high-quality graphite electrodes.

105A Technical Services. Laboratory and pilot plant testing, flowsheet preparation, economic analysis, complete plant design and construction. Bulletin from Dorr-Oliver, Inc.

106L Jet Ejectors. To create vacuum, increase pressure, or to mix gases. No moving parts. Bulletin from Ingersoll-Rand.

(Continued on page 76)

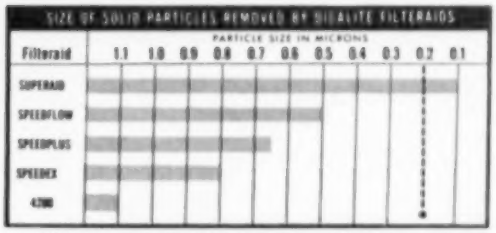
It may pay you to read this

When anything has been long established – as have the advantages and properties of Dicalite Filteraids – there is a tendency for some of the details to slip the mind. Hence, this two-minute reminder may be of very present value on your problems of today or tomorrow.

Dependable GLC GREAT LAKES **Dicalite**® DIATOMACEOUS MATERIALS

Sharp Filtration

As the chart shows, Dicalite Filteraids can remove *all* unwanted particulates, even those down in the sub-micron range, to give unsurpassed clarity of filtrate.



*0.2 MICRON – Theoretical limit of resolution of optical microscope. Few microscopes achieve it.
60.0 MICRONS – Smallest particle size visible to the unaided eye at 10" distance.

Fast Flowrates

Since a Dicalite filtercake is 85 to 90% voids – only 10 to 15% solids, and relatively incompressible – flowrates are fast for full production.

Full Range of Grades

By selection of the correct Dicalite Filteraid (there are 9 grades, with relative flowrates from 1 to 20) any process liquor may be economically filtered to required clarity with optimum throughput.

Chemically and Physically Stable

Being practically pure SiO_2, processed from high-grade crude diatomite, Dicalite Filteraids are inert in acid and aqueous solutions.

Uniform Quality

All Dicalite Filteraids are highest quality, and the industry's most exacting quality-control processing maintains the particle size range and distribution of every grade dependably uniform, lot after lot.

If you have not completely investigated the advantages of Dicalite in your processing, write for Dicalite Bulletin B-13, which discusses the practical applications of Dicalite Filteraids in processing.

DICALITE DEPARTMENT • Great Lakes Carbon Corp.
612 South Flower Street • Los Angeles 17, California

PRODUCTS ADVERTISED IN THIS ISSUE (*Cont.*)

106BR Laboratory Furniture and Equipment. 180-page catalog from Metalab Equipment Co. describes complete line of laboratory equipment and furniture.

107A Turbo-Dryer Systems. From packaged pilot plant units with 60 sq. ft. tray area to giant outdoor units with 18,000 sq. ft. Wyssmont Co.

108TL Metallic Raschig Rings. Available in all workable metals, custom produced to most exacting specifications. Samples on request. Metallo Gasket Co.

108BL By-Products Purchased or Refined. Truland Chemical Co. specializes in economical upgrading and disposal of solvent mixtures and organic by-products. Bulletin.

109A Sales Service. The sales service offered by Proctor & Schwartz, Inc. is the final phase in the consideration of a drying problem.

120L Heat Exchangers. For heating, cooling, air conditioning, and process requirements. Aerofin Corp.

121TL Heating Coil Assemblies. In lead, copper, aluminum, stainless steel, and carbon steel. Engineering data book on pipe and fin coils. Rempe Co.

121TR Spray Nozzle Catalog. Comprehensive data on chemical and industrial spray nozzles and related equipment. Spraying Systems Co.

121B Welded Chemical Vessels. Tanks, pressure vessels, chemical and processing equipment in aluminum, stainless, carbon steel, Monel, other alloys. Literature from R. D. Cole Manufacturing Co.

122TL Steam-Jacketed Gear Pumps. To handle viscous materials of many types—heavy fuel oils, asphalt, vegetable shortening, glue, many others. Bulletin from Schutte and Koerting Co.

129A Nuclear Reactor Components. Superior Tube specializes in design and construction of intricate reactor components of special types. Technical data.

130TL Thermocouple Connector Panels. Provide flexible, centralized control for any number of thermocouples. Bulletin from Thermo Electric Co.

130BL Continuous Weighing Belt Feeder. Handles all materials from free-flowing to sticky. Rates from pounds to hundreds of tons/hour. Data from Thayer Scale Corp. on the Autoweightion.

131R Rubber and Plastic Processing Equipment. Eleven job-proved rubber and plastic materials now available in ACE piping, valves, pumps, and tanks. Bulletins from American Hard Rubber Co.

137TR Panel Heating Coils. Dean Thermo-Panel coils can replace old-style pipe coils with advantage in many processing applications. 52-page bulletin with price and design data from Dean Thermo-Panel Coil Division, Dean Products, Inc.

DEVELOPMENTS OF THE MONTH (*Cont.*)

370 Triple-Stage Vapor Fractometer. Perkin-Elmer Corp. introduces a new instrument which, for the first time, makes possible the single run analysis of a sample containing a large number of components which boil over a wide range. The instrument is designed to take three rough cuts of a total sample without need for preseparation and to make three simultaneous analyses under optimum chromatographic conditions. A wide range sample is introduced into the first operational stage. That part of it which is best separated under the selected conditions is analysed. Those components not resolved are fed directly into a second stage under a different set of conditions for further analysis. Any portion still unresolved may then be fed into the third stage. Each stage is provided with its own recorder to indicate those bands separated. Since there is overlap in the readout of the three stages, calibration with a single sample is possible. Two of the three column units are equipped with precision gas sampler valves, facilitating the injection of reproducible samples of 0.25, 1.0, 5.0 or 25 cu. cm. at reduced, atmospheric, or elevated pressures. Two units also contain heaters and blowers for control of air bath temperatures. One unit is designed to operate at any selected column temperature from ambient to 300°C., a second offers selection between ambient and 225°C., and a third is modified for use with refrigeration baths and may be operated at any specified temperature.

Further technical details on the instrument are available from the manufacturer. Circle number 370 on Data Post Card.

110L Electromagnetic Bin Vibrators. Syntron bin vibrators available in sizes to handle from 1 cu. ft. hoppers to large bins and bunkers. Catalog from Syntron Co.

115R Heat Exchangers. Graham Manufacturing Co. offers consulting services on selection of proper "Heliflow" heat exchangers.

116L Corrosion-Resistant Equipment. Heat exchangers, process tanks, fume ducts, piping, pumps, valves. Haveg Corp.

117L Industrial Dryers. Development, design, and fabrication of all types for the process industries. Detailed information from C. G. Sargent's Sons Corp.

117R Control Valves. Built-in positioner, "O" ring piston, totally-enclosed operator, straight-thru flow. In sizes from ½ through 20 in. DeZurik Corp.

119A Vinyl Resins. Complete information and technical service from Chemical Sales Division, Firestone Plastics Co.

122BL Drum Reconditioning Machines. Gilco Model VSDD-56 Vacuum Syphon Drum Dryer removes residue rinse water and dries drums in one operation. Complete details and specifications from L. M. Gilbert Co.

123BL Gauge Glass and Cylinders. Supplied in any length or finish from 2 mm. O.D. to 7 in. O.D. Swift Glass Division, Swift Lubricator Co.

123R High-Pressure Compressors. From single stage to six stages, from 125 to 25,000 lb./sq.in. Catalog from Norwalk Co.

124L Steam Tube Dryers. In aluminum, nickel, Monel, Inconel, stainless steels, other alloys. Complete specifications in bulletin from Hardinge Co.

125R Rotary Positive Blowers. In capacities from 5 to 100,000 cu. ft./min. of accurately-controlled air. Bulletin from Roots-Connersville Blower.

137BR Corrosion-Resistant Pipe. For pressures to 1,000 lb./sq.in., temperatures to 250°F. Details on Fibercast pipe and tubing from the Fibercast Corp.

IBC Technical Planning Services. Economic studies, geological surveys, raw material investigations, site selection, research and development, etc. Also engineering, design, and construction services. Ralph M. Parsons Co.

OBC Technical Data on Mixing. Bulletins from Mixing Equipment Co. give full technical details on all types of "Lightnin" mixers.

A.I.Ch.E. MEMBERSHIP

Brochure—"Know Your Institute"—tells objective aim and benefits to chemical engineers who join this nation-wide organization, includes membership blank. Circle number 371 on Data Post Card.

ARE YOU SATISFIED WITH...

1. WE WILL MANUFACTURE TO YOUR DRAWINGS.
2. WE OFFER OUR STANDARD DESIGNS.
3. WE WILL DESIGN TO MEET YOUR SPECIFIC NEEDS.
4. WE WILL CO-ORDINATE YOUR IDEAS AND OUR KNOW-HOW

WORK MADE TO YOUR DRAWINGS?

CAST IRON AGITATOR FOR CORROSION RESISTANCE IN DYESTUFFS FIELD.

Here are three examples of jobs where the manufacturers had difficulty in obtaining what they needed—until they came to Bethlehem Foundry & Machine Company.

Then the manufacturers found they got from Bethlehem the workmanship and materials they required.

Bethlehem works in cast iron, ductile iron, fabricated steel, stainless steel, and alloys, to meet ASME code requirements.

At Bethlehem you get wide engineering experience and skill in design and selection of materials, coupled with complete manufacturing facilities.

Drop us a line regarding your requirements.

CORROSION RESISTANT CAST IRON VESSEL —— ASME CODE REQUIREMENTS.

HALF ROUND HEATING COIL WELDED TO COVER OF DRYER.

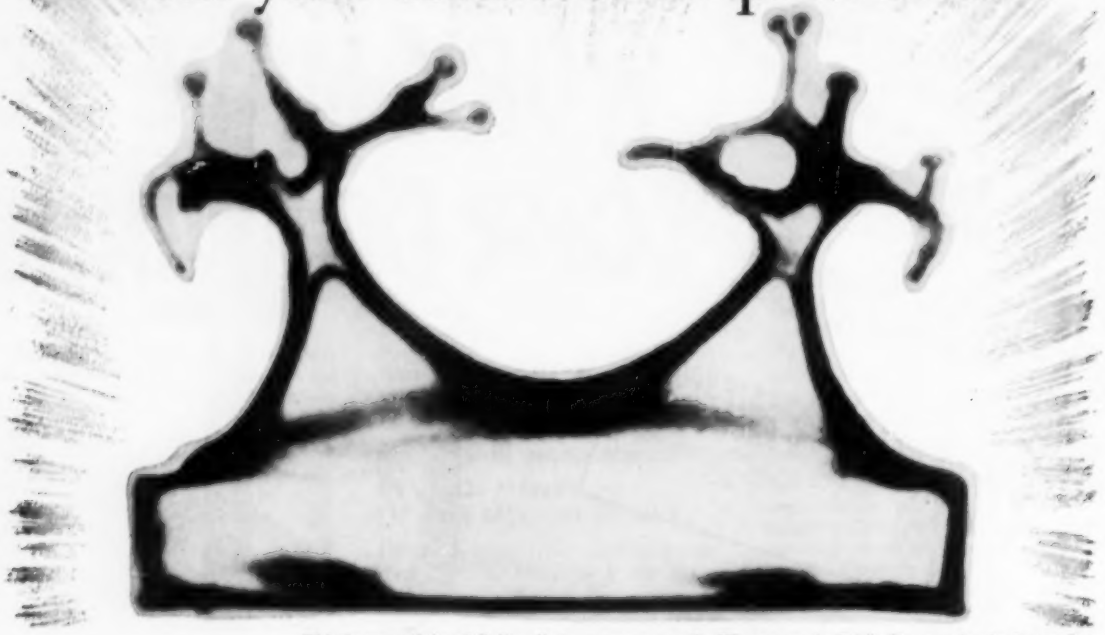
BETHLEHEM FOUNDRY & MACHINE CO.

Process Equipment Division
Bethlehem, Pennsylvania

ENGINEERS
MACHINISTS
FABRICATORS
FOUNDRYMEN

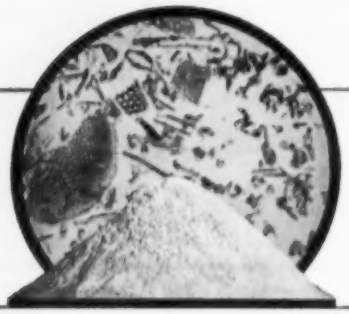
BETHLEHEM FOUNDRY & MACHINE COMPANY
B
ESTABLISHED 1866

What's this "CROWN" got to do with your formulation problems?



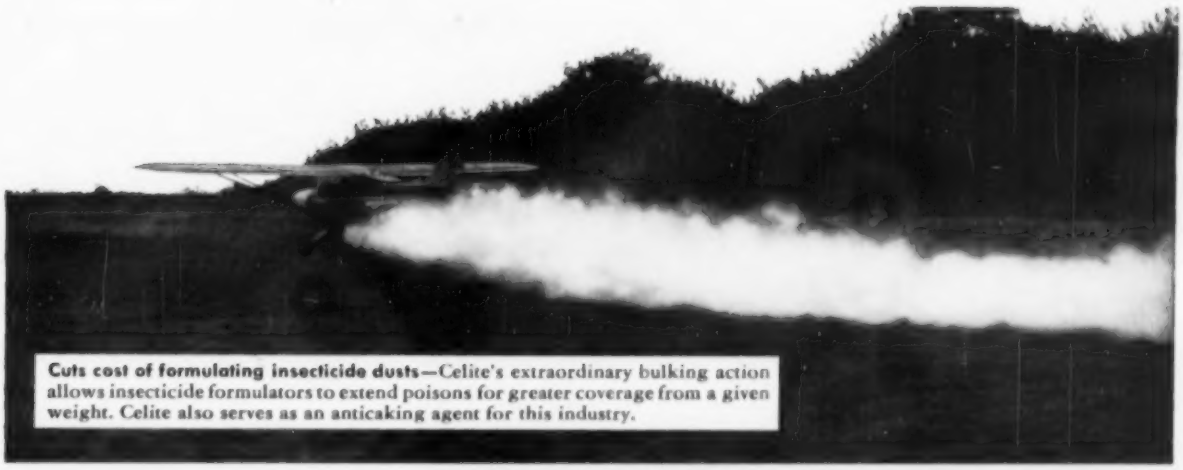
This is a particle of Celite diatomaceous earth. The genus is *Dicladia,* species is *Capreolus.* Loosely translated it means "two-sided branch." This particle is just one of hundreds of different intricate particles that together make Celite such an efficient mineral filler. When placed under a microscope *Dicladia Capreolus* becomes a rustic "crown."

It's a particle of CELITE with a cubic foot



The secret of diatomite's remarkable properties—The infinite variety of particle shapes and sizes gives Celite diatomite its exceptional performance characteristics in a wide range of process applications. Irregular shapes like the "crown" prevent packing down for high bulking action.

Johns-Manville CELITE



Cuts cost of formulating insecticide dusts—Celite's extraordinary bulking action allows insecticide formulators to extend poisons for greater coverage from a given weight. Celite also serves as an anticaking agent for this industry.

Controls package loss in cleansers—Cleansers and other powder products remain "fluffed up" after packaging when formulated with Celite. Celite also serves as an absorbent for detergents, wetting agents and odorants.

Adds needed bulk to paper—Because of its exceptionally low apparent density, Celite increases bulk in paper as much as 10% with a corresponding increase in machine speed. Celite is also used in paper mills to control pitch and improve brightness, opacity and ink receptivity.

—the inert mineral filler of bulk in every ten pounds

AS MUCH AS 10 TIMES greater bulking action than any other mineral filler. That's what you get when you formulate with Celite®. Composed of microscopic irregularly shaped particles of diatomite that won't pack down, Celite contains as much as 93% air space or voids in a given volume. And with its low cost per unit volume, Celite gives you far more bulk per dollar than other mineral fillers.

Many important filler applications are derived from Celite's unique properties. Its light porous mass provides great absorptive capacity, permitting preparation of high concentrate insecticides and other liquids in a dry, free-flowing powder form. The vari-shaped microscopic particles have large surface areas which serve to extend pigments in paint and paper-making. Other important uses include molded plastics, matches, concrete, acetylene tank fillers and adhesives.

Produced from the world's purest commercially available diatomite deposit, Celite comes in a wide range of grades. Each grade is carefully controlled for complete uniformity.

Ask your local J-M Celite engineer to tell you how Celite can help solve your formulation problems. He's backed by Johns-Manville's extensive research facilities and years of practical diatomite experience. Call him today or write Johns-Manville, Box 14, New York 16, N. Y. In Canada, write Port Credit, Ontario.

*Celite is Johns-Manville's registered trade mark for its diatomaceous silica products.

Industry's most versatile MINERAL FILLERS

JOHNS-MANVILLE JM PRODUCTS

Mr. Gene Lane, Utility Operator, at the Central Soya Co., Inc., Chattanooga, Tenn. plant, operates 36 Merchen Scale Feeders that blend feed ingredients to 1% accuracy.

MERCHEN SCALE FEEDERS

"give us accurate, continuous blending over a wide feed range"

Central Soya Co., Inc., blends millions of bags of animal and poultry feed a year at their new Chattanooga plant. Up to 50 different formula feeds are produced to exacting standards. Central Soya chose W&T Merchen Feeders because they give 1% minute-to-minute accuracy over a wide feed range. As seen in the picture, the feeders are compact — with no bulky enclosures.

Merchen Scale Feeders, with feed rates from 3 to 3000 pounds per minute, require no adjustment for changes in material density. They are suited for most industrial continuous blending or automatic batching processes. For more information about Merchen Scale Feeders, write for Bulletin M-34.

WALLACE & TIERNAN INCORPORATED

25 MAIN STREET, BELLEVILLE 9, NEW JERSEY

ABSOLUTE PRESSURE INDICATOR

For Precise Vacuum Work

Ranges: From 0—50 mm to 0—800 mm Hg. absolute in six ranges
Accuracy: 1/300 of full scale
Sensitivity: 1/500 in *all* ranges
Dial Size: 2¾" or 6" diameter

NOW AVAILABLE FROM STOCK

WALLACE & TIERNAN INCORPORATED
25 MAIN STREET, BELLEVILLE 9, N. J.

TYPE FA-160

Write for Publication No. TP-28-A

BROWNSVILLE SHUT-DOWN

(Continued from page 56)

operating data and equipment inspection. In addition, catalyst losses were reduced to a negligible value. This work was confirmed in several runs in the activation unit.

Summarized results from a typical test in the activation unit are:

Feed rate, per cent of design ..	100
Average yields, per cent of design	
Water-soluble chemicals ...	103
Stabilized synthetic oil	92
Polymer gasoline	93

With further minor revisions, design yields could be obtained, at least in this smaller reactor. In fact, some recent developments have shown equal or greater promise than those already proven in the activation reactor. These developments were being tested at the time of plant shutdown.

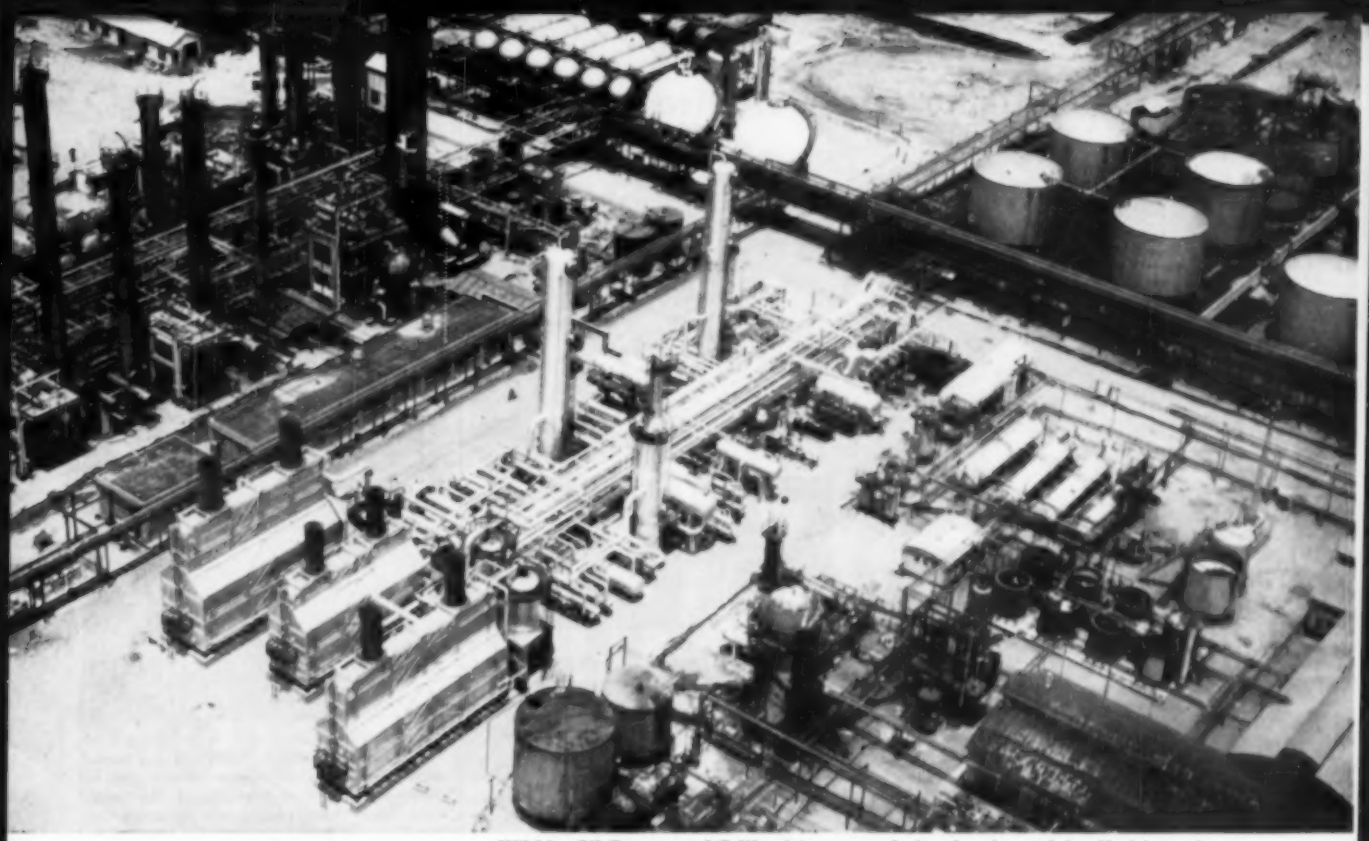
Several months ago, designs were completed to permit translation of results from the activation reactor to the larger synthesis reactors. This step appeared easy because of the similarity between the activation and synthesis reactors and the relatively small scale-up (from an 8 ft. to a 16 ft. diam. reactor). From an overall viewpoint, the results indicate that technical feasibility of the hydrocarbon synthesis reaction with fluidized catalyst has been demonstrated.

Economic Factors

Three main factors prevented attainment of the goals established in 1954 for the Brownsville plant. These factors, all of which affect process economics unfavorably, are:

- **The repairs and modifications of the Carthage plant and the installation of new equipment took substantially more time and money than had been anticipated.**
- **After operations were begun, the necessity to develop solutions to the major technical problems previously discussed. During this time, normal operating costs continued with little offsetting income from production.**
- **Rising costs of equipment, labor, and raw materials without corresponding increases in product prices.**

The foregoing reviews the more important operating problems encountered at the Brownsville plant. In general, solutions to these problems were found. Based on tests in an eight-foot reactor, it appeared that development of a practical solution to the last major problem —good gas-solids contacting—was nearing completion. However, even at lined-out conditions the plant would have cost substantially more to operate and maintain than had been forecast.



Wilshire Oil Company of California's new catalytic reforming and desulfurizing units at Norwalk, designed and constructed by SWECO to produce high-octane motor fuel.

Teamed to Upgrade Lowgrade

Working together, Wilshire Oil Co. of California and SWECO have been solving process problems since 1923. They've done it again with this new 10,000 BPD Platformer-Unifiner for premium-quality gasoline.

To help satisfy the growing thirst of modern auto engines for higher octane fuels, Wilshire Oil Co. of California decided to add a new catalytic reforming unit at its Norwalk plant. Design and construction were placed in the hands of SWECO's Engineering and Construction Division. A logical choice. The two companies have been working together since 1923, when SWECO built an absorption plant for Wilshire at Santa Fe Springs. And for 34 years, SWECO had been supplying Wilshire with heat exchangers and other process equipment. SWECO was a known *dependable* quantity.

High temperature, high pressure

The Norwalk project was a 10,000 BPD Platformer-Unifiner to upgrade low-octane naphthas. Temperature and pressure requirements were high: The Platformer – using platinum as a catalyst to reform the molecular structure of hydrocarbons–required 975°F., 650 psig. The Unifiner – freeing sulfur from the naphtha to permit high-severity reforming – required 675°F., 850 psig. To meet process requirements, SWECO supplied 13 heat exchangers, designed and manufactured at its Los Angeles plant.

Signed, sealed and "on stream"

Approximately 13 months after SWECO engineers went to work, the Norwalk unit went "on stream." (Total elapsed time included 7 months of field construction.) It's a typical SWECO job. Done right, and done right on time, whether it's in Tanganyika, the Andes, or around the corner in Norwalk, California.

Typical also of SWECO teamwork on all jobs . . . in *engineering and construction* of refineries, chemical plants and ore beneficiating mills . . . in the design and manufacture of *process equipment* . . . in a complete line of *vibrating screen separators* . . . or *extended service* in plant modernization; procurement and expediting; plant operation.

For more information on how SWECO teamwork may help your engineering and construction needs, write for Brochure E-5-29.

SWECO

Southwestern Engineering Company

4800 Santa Fe Avenue, Los Angeles 58, California

Engineers and Constructors . . . Manufacturers

Does your work concern protective coatings?

from carboline

handy gauge measures wet film thickness of protective coatings

Ordinarily, the final thickness of a protective coating is unknown until the coating has cured, or dried. Then it is often discovered too late that the film is too thin. The result? An additional coat must be applied or the coating fails prematurely. Either way, it is costly and inconvenient.

But now you can avoid such trouble, with this new contribution to Carboline's Engineering Approach to corrosion protection. This precision-ground gauge allows you to accurately measure (.0015" tolerance) **wet** film thickness **during** application, determine final dry thickness, and make any necessary adjustments **immediately.**

If your work concerns protective coatings, request this essential gauge (one per request while our supply lasts). There is no obligation.

Write Today on Your Company Letterhead

carboline COMPANY

335 Thornton Ave., St. Louis 19, Mo.

Manufacturers of PHENOLINE, POLYCLAD, RUSTBOND PRIMERS

Specialists in Corrosion Resisting Coatings and Linings

INDUSTRIAL NEWS

Aluminum-coated sheet steel is being used as a weather shield with high strength and corrosion resistance on a reformer reactor and a cracking unit catalyst disengager in the Beaumont, Tex., refinery of Magnolia Petroleum Co. Supplied by Armco Steel Corp., the aluminized steel protects the 13 ft. 9 in. diameter, 90 ft. high reactor from driving winds and rain, provides insulation by reflecting radiant heat. The 14 ft. by 30 ft. catalyst disengager atop a 230 ft. tower is similarly protected.

A new plant for production of dichlorocyanuric acid, trichlorocyanuric, and the sodium salt of dichlorocyanuric acid will be erected at Charleston, W. Va., by Westvaco Products Division of Food Machinery & Chemical Corp. Scheduled for operation in July, 1958, the plant will have an annual capacity of 6,000,000 pounds. The products, which have a high percentage of available chlorine, are used in household dry bleaches and scouring powders, commercial laundry bleaches, and germicidal compounds. □

All field work for Freeport Sulphur's $119,000,000 nickel-cobalt project in Moa Bay, Cuba, has been contracted for by Frederick Snare Overseas Corp. Overall productive capacity of the plant will be 50,000,000 pounds of nickel and 4,400,000 pounds of cobalt annually. □

Vinyl acetate monomer production will be raised from 30,000,000 to 45,000,000 lb./yr. at the Calvert City, Ky., plant of Air Reduction Chemical Co. Vinyl acetate monomer is a basic constituent in resins for water-based paints, adhesives, textile treating compounds, paper sizing, and interlayers for automobile safety glass. □

40 Forward Years FOR CROLL-REYNOLDS

1917 Croll-Reynolds Co. established; work on EVACTORS, started previously by the two founders, now enters new phase.

1920's Croll-Reynolds contributes greatly to the power field's efficient use of intercondensers between stages for steam economy.

1930's Croll-Reynolds focuses on the need for high vacuum in the growing chemical field—gives special attention to design of 4 and 5 stage EVACTORS, and also to the application of steam jet refrigeration equipment.

1940's Croll-Reynolds directs activity toward war effort, supplies a great number of EVACTORS for shipboard use, special units for the atomic program, and equipment for manufacturing new types of explosives and chemicals. **In the late 1940's,** Croll-Reynolds develops and supplies vacuum equipment for vacuum cooling of fresh vegetables.

1950's Croll-Reynolds develops special condensing tower used to recover entrained materials and to prevent contamination of cooling water—especially adaptable for deodorizers in the fatty acid and allied industries.

PRESENT Croll-Reynolds continues to develop and perfect new kinds of jet and condensing equipment with the knowledge and skill that has enabled the Company to establish an enviable record. In its Forty Forward Years, Croll-Reynolds has—

- Supplied equipment for vacuum cooling of fresh vegetables with a combined **daily** capacity of 2000 cars **each** holding 25,000 to 30,000 lbs.
- Designed and manufactured **all** the commercial vacuum cooling equipment **used** to date in the electrolytic zinc industry of the U. S. and Canada.
- Supplied **more** vacuum cooling systems for the Viscose-Rayon industry than **all other manufacturers combined.**
- Pioneered many new applications of vacuum and vacuum refrigeration.

Croll-Reynolds Company, Inc. is confident that in the future, as in the past, they will continue to develop new types of industrial jet equipment and improve existing designs.

CROLL CHEMICAL REYNOLDS

Croll-Reynolds CO., INC.

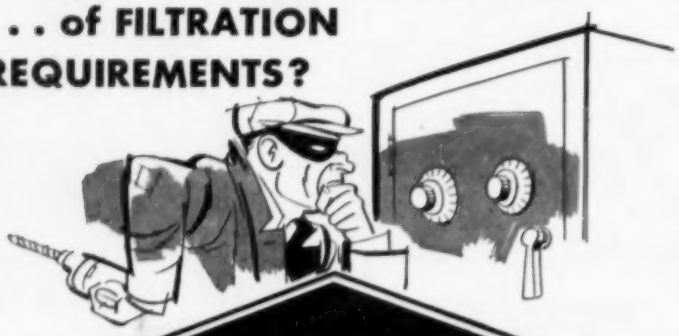
Main Office: 751 Central Avenue, Westfield, N. J.

New York Office: 17 John Street, N. Y. 38, N. Y.

CHILL-VACTORS • STEAM-JET EVACTORS • AQUA-VACTORS • FUME SCRUBBERS • SPECIAL JET APPARATUS

Stopped by a TOUGH Combination...

... of FILTRATION REQUIREMENTS?

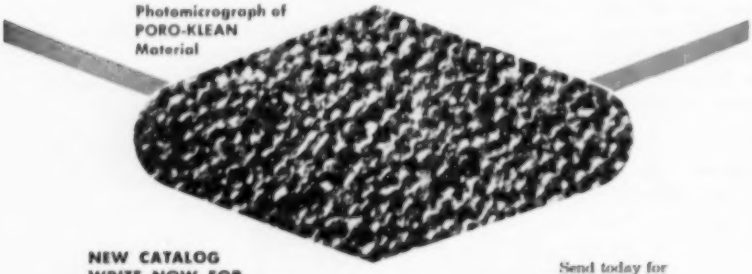


CUNO

PORO-KLEAN

THE POROUS STAINLESS STEEL MEDIUM THAT OFFERS YOU ALL THESE ADVANTAGES —

- **HIGH HEAT RESISTANCE** . . . permitting operation at temperatures as high as 900°F.
- **HIGH TENSILE STRENGTH** . . . up to 15,000 psi, allows Poro-Klean Filters to withstand differential pressures of more than 3500 psi and to handle extremely viscous liquids at relatively high flow rates.
- **HIGH CORROSION RESISTANCE** . . . allows the filtration of — or cleaning by — substances that would quickly damage other filter materials.
- ***NO* MEDIA DISCHARGE** . . . Cuno's unique manufacturing and control methods result in a much stronger material with *all* particles securely bonded at several points of contact. Independent tests have *proved* that Poro-Klean produces no product contamination due to media discharge . . . even under conditions of extremely high differential pressures and severe vibration.
- **UNIFORM FINE FILTRATION** . . . with standard material down to 5 microns. Material for sub-micronic filtration available on special order.



Photomicrograph of PORO-KLEAN Material

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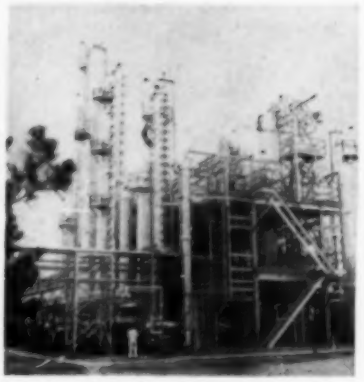


Truck-load quantities of neopentyl glycol have been delivered to a large polyester manufacturer in the Southeast by Eastman Chemical Products, Inc. The shipment marks the completion of Eastman's first, full-scale production facilities at Longview, Texas, where the new 5-carbon glycol is being turned out.

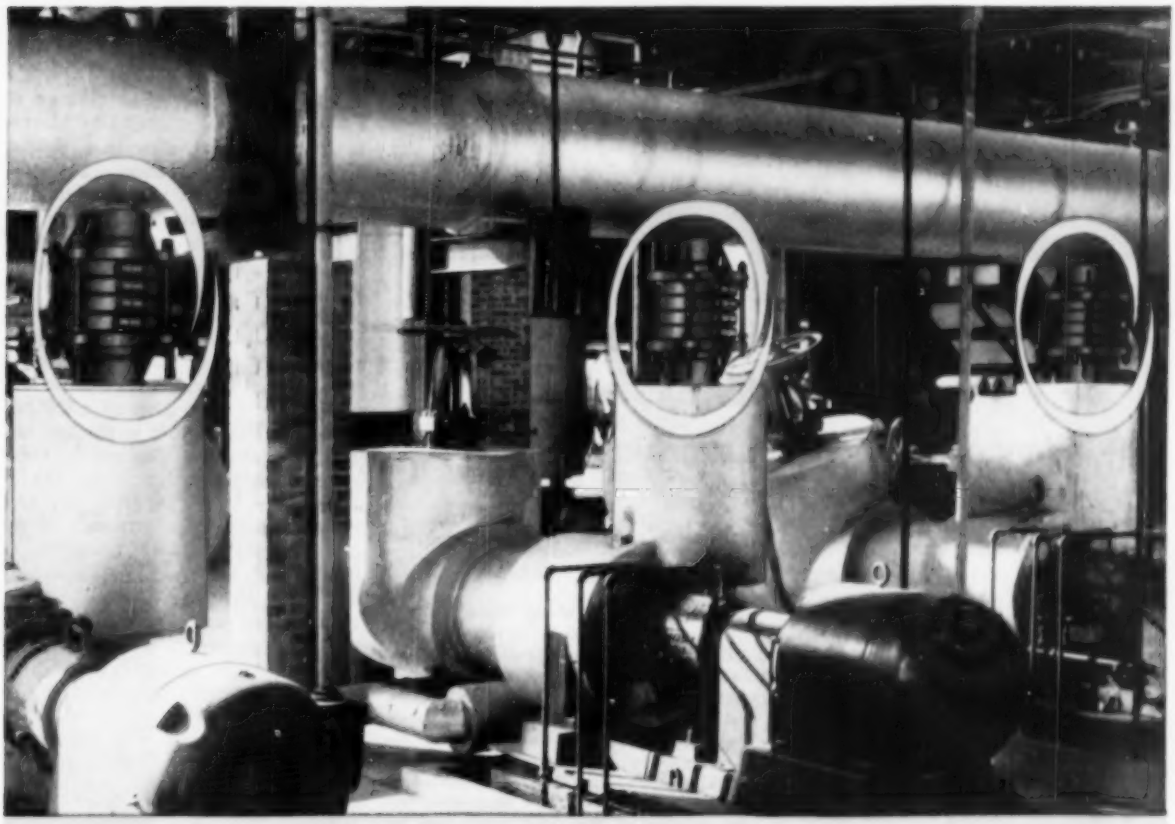
High energy fuel components are being explored in a joint venture by Hooker Electrochemical Co. and Foote Mineral Co. Present studies are concentrated on lithium perchlorate and ammonium perchlorate, oxidizing materials for rocket and missile fuels. Later studies may be extended to other high energy fuel components. Basis for joint action is Hooker's ownership of Oldbury Electro-Chemical Co., large chlorate manufacturer, and Foote's position as the world's largest producer of lithium metal and its salts. □

Haveg Industries has acquired Reinhold Engineering and Plastics Co., Norwalk, Conn., producers and fabricators of corrosion-resistant chemical processing equipment and of plastics for the aircraft-missile industry. □

Expansion plans are already being mapped for Firestone's four-month old butadiene plant in Orange, Texas. With a yearly capacity of 40,000 tons, the present plant supplies most of the butadiene for the company's synthetic rubber plants at Lake Charles, La. (capacity 190,000 tons a year), and Akron, Ohio (capacity 40,000 tons). □

A newly-formed division of Research Instrument Corp., Analytic Systems Co., will develop, manufacture, and sell industrial instruments for process stream analysis. □

Metal processing chemicals, sanitizing agents, laundry and dry cleaning chemicals, and other specialty products will be distributed in Canada from Pennsalt Chemicals' projected plant near Oakville, Ontario. □



ADSCO CORRUFLEX EXPANSION JOINTS SOLVED A PIPING PROBLEM FOR NATIONAL ANILINE

The new $20,000,000 diisocyanates plant of the National Aniline Division, Allied Chemical & Dye Corp., at Moundsville, W. Va., is known for many engineering wonders, especially its miles of intricate piping. The photo above shows three ADSCO Corruflex anti-compression packless expansion joints used to secure satisfactory piping connections between the main piping and three pumps.

If rigid piping had been used to connect the three pumps to the 18-inch main feeder, the piping soon would have been twisted and overstressed by the growth of the main feeder when hot process liquid was pumped through it. National Aniline engineers, in consultation with ADSCO engineers, decided to use the anti-compression joints shown in the photo. These are deflected laterally with minimum strain on the connecting piping and pumps as the main feeder expands or contracts. Also, the joints absorb vibration of the pumps and motors.

For efficient, right-working pipe line arrangements, use ADSCO Corruflex expansion joints. Packless, they require no maintenance. Sizes, 3" to 54"; for temperatures to 1600 F and pressures to 300 psi.

REMEMBER! Use ADSCO Expansion Joints instead of Pipe Bends because of these advantages:

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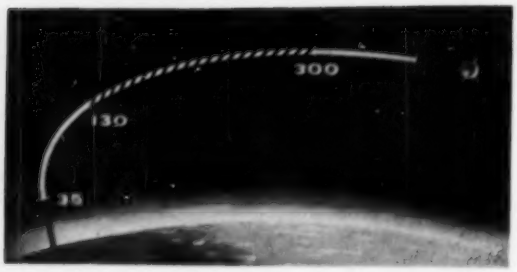

Drawing of flight plan projected for Vanguard satellites.

CHEMICAL ROCKET PROPULSION in the Vanguard Satellite Launching Vehicle

Joseph E. Burghardt * | The Martin Company, Baltimore, Maryland

Project Vanguard, the implementation of the Scientific Earth Satellite Program for the International Geophysical Year, is more than ever in the public eye since the successful Soviet launching of its first satellite.

On September 23, 1955, the Navy awarded the prime contract for design and construction of the satellite launching vehicles to the Martin Company of Baltimore, Maryland. This problem confronted Martin Engineering: the creation, in a minimum of time, of a vehicle capable of transporting a 21½-lb. payload to an altitude of about 300 statute miles, imparting to it a velocity in excess of 17,000 miles/hr. and pointing it in a direction parallel to the earth's surface within an accuracy of about plus or minus two degrees.

The Vanguard launching vehicle configuration as it exists today is about 71 ft. long with a basic diameter of 45 in. in the first stage and 32 in. in the second stage. Its weight, fully loaded for launching, is approximately 22,600 lb.

Stage 1

The first stage is simply a large propulsion system, consisting of the General Electric X-405 liquid propellant rocket engine, combined with Martin propellant tankage, pressurization, and control systems. It is designed for a nominal burning time of 150 sec., utilizing kerosene as fuel and liquid oxygen as oxidizer. System details are shown schematically in Figure 1.

The X-405 engine, designed and manufactured to Martin specifications by the Aircraft Gas Turbine Division of GE, has a minimum thrust rating of 27,000 lb. at sea level. This thrust figure, of course, increases with altitude, reaching a value in vacuum of well over 30,000 lb. The steel thrust chamber is cooled regeneratively by the fuel (kerosene) which flows through helical passages between the chamber's inner and outer shells on its way to the injector head. The chamber is mounted on gimbals and is hydraulically actuated so that the direction of the thrust vector may be changed to provide pitching and yawing moments which control the vehicle's attitude during first-stage flight. The engine incorporates a turbopump, which delivers the propellants from the tanks into the thrust chamber and also drives the hydraulic pump for the control system. Power for the turbopump is derived from high-temperature steam, which is provided by the decomposition of concentrated (90 per cent) hydrogen peroxide as it passes through a silver-screen catalyst chamber. This same steam, after being exhausted from the turbine, is ducted outboard to two small swivelling jet nozzles which normally point aft, but are capable of being rotated 45 deg. in a vertical plane to provide roll control.

The integral propellant tankage is designed and manufactured by Martin in 6061 aluminum alloy in a welded monocoque configuration. The attendant plumbing, vent valves, fill connections, etc., are shown in Figure 1. The welded aluminum peroxide tank and associated plumbing are mounted just forward of the engine.

Helium pressurization is used in the first stage for several different purposes: (1) to actuate the peroxide flow through the catalyst chamber and turbopump; (2) to pressurize the gas space above the liquids in the fuel and oxidizer tanks, and thus control pressures at the turbopump inlets; (3) to actuate the swivelling roll jets and various propulsion system valves pneumatically; and (4) in the crucial few seconds at burnout and during first-stage separation to augment the deteriorating turbopump exhaust as the working medium for the roll jets. The helium is originally stored at about 4,400 lb./sq.in. gauge in two steel spheres just aft of the fuel tank, and is piped through suitable pressure-regulating valves to perform its various functions.

Stage 2

The second stage propulsion system, shown schematically in Figure 2, is likewise a liquid rocket, but otherwise has very little in common with the first. Second-stage engine, tankage, and pressurization system have been subcontracted in a single propulsion system package, designed and

(*Continued on page 88*)

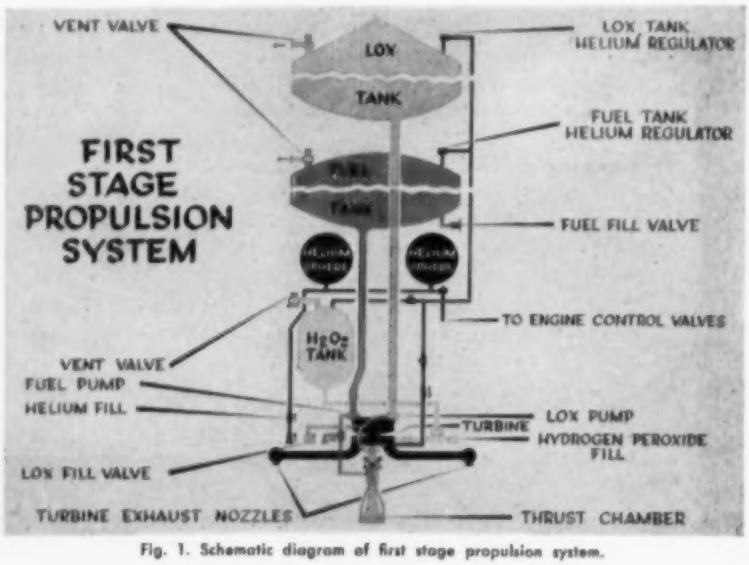

Fig. 1. Schematic diagram of first stage propulsion system.

* Mr. Burghardt is assistant project engineer for Flight Aerodynamics and Propulsion on Project Vanguard.

What happened to the price of oxygen?

The price of bulk oxygen has dropped about 80% in 12 years, while most other prices have risen. Oxygen is now being produced in large quantities for a few dollars per ton.

Oxygen isn't the high-priced chemical it used to be. Now, it's a low-priced tonnage commodity—a utility purchased like electricity or water. The price drop is the *real reason* oxygen usage has climbed beyond 70 billion cubic feet per year.

Why was it costly?

Transportation costs, storage, outside labor involvements and the other limitations of outside supply added expense and uncertainty to hauled-in-oxygen. Trucks and tank cars are still in use, but today's major savings result from Air Products *on-location* generation.

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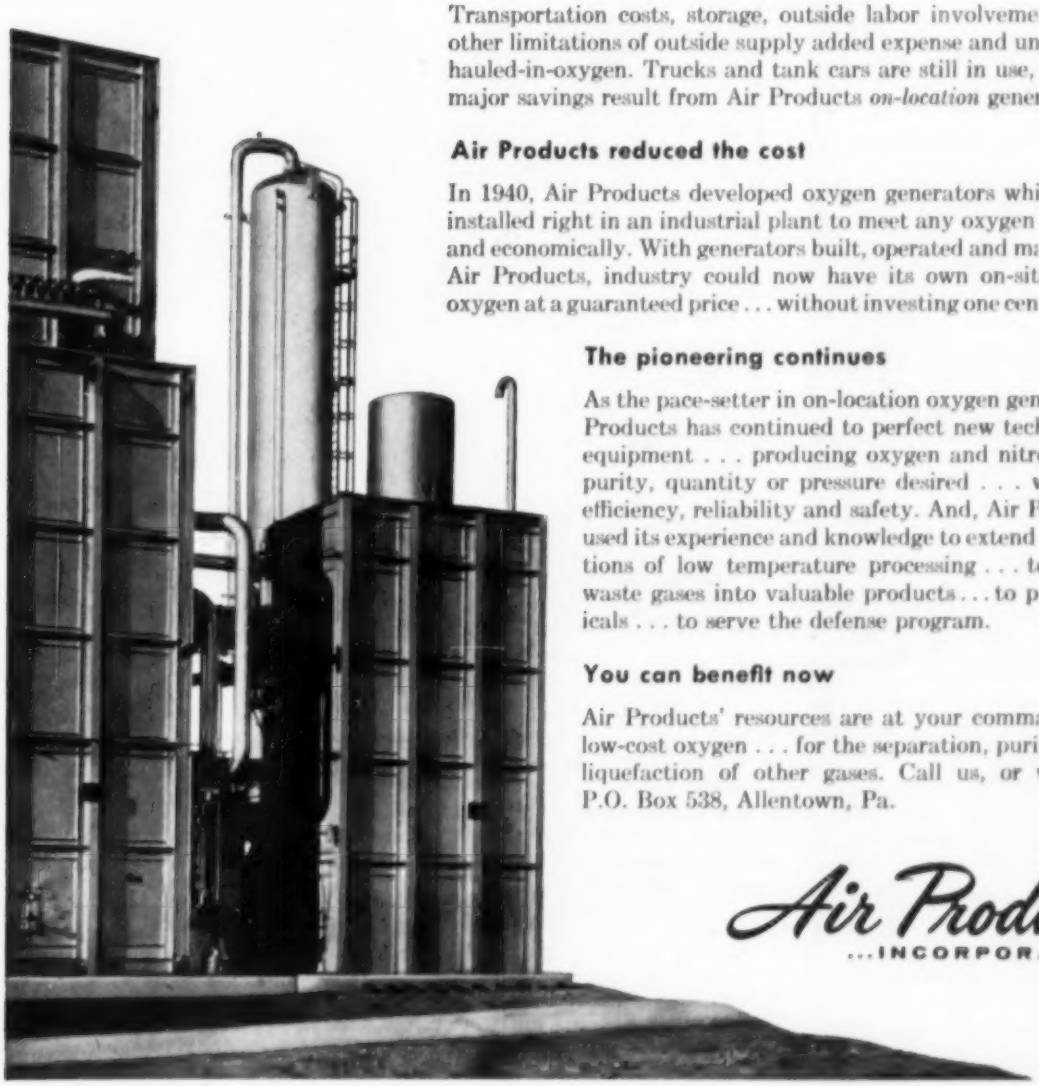
In 1940, Air Products developed oxygen generators which could be installed right in an industrial plant to meet any oxygen need, safely and economically. With generators built, operated and maintained by Air Products, industry could now have its own on-site supply of oxygen at a guaranteed price . . . without investing one cent of capital.



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As the pace-setter in on-location oxygen generation, Air Products has continued to perfect new techniques and equipment . . . producing oxygen and nitrogen in any purity, quantity or pressure desired . . . with greater efficiency, reliability and safety. And, Air Products has used its experience and knowledge to extend the applications of low temperature processing . . . to transform waste gases into valuable products . . . to purify chemicals . . . to serve the defense program.

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VANGUARD SATELLITE

(Continued from page 86)

manufactured to Martin specifications by Aerojet-General Corporation. It was hoped originally that an Aerobee-Hi power plant nearing completion at that time would meet the requirements for this stage. However, this power plant could not be modified to meet the strenuous requirements specified.

The Aerojet AJ10-37 propulsion system is designed for a nominal burning time of 120 sec., utilizing unsymmetrical dimethyl - hydrazine (UDMH) as fuel and white fuming nitric acid (WFNA) as oxidizer. These propellants are "hypergolic"—that is, they react spontaneously and violently upon the slightest contact. This unpleasant characteristic obviously multiplies the problems of propellant handling, but on the other hand, it minimizes the problem of assuring successful ignition of the stage in the near-vacuum environment in which it must operate.

The thrust chamber is rated at a minimum of 7,500-lb. thrust in vacuum, and is of the "tube-bundle" type design. This means that the tubes are shaped to the desired contour, welded together and wire-wrapped, in a configuration such that the nitric acid passes through the tubes on its way to the injector, and thus provides regenerative cooling of the chamber. Again, as in the first stage, the chamber is gimballed and hydraulically actuated to provide vehicle pitch and yaw control during powered flight.

The tankage is of welded 410 stainless steel, arranged with its plumbing as shown in Figure 4. The fuel and oxidizer tanks are separated by a sphere of high-pressure helium, which in this case provides the primary motive power for propellant flow. No mechanical pump is used for this purpose in the second stage.

The pressurization system performs one other function—in the coasting period that follows second-stage burnout, the residual helium in the tanks (still at fairly high pressure) is utilized as the working medium for a number of small gas jets which provide attitude control moments for the vehicle about all three major axes. Some of these same jets also function to provide roll control during second-stage powered flight, during which time their working medium is propane gas, stored in liquid form in a small tank just forward of the UDMH tank.

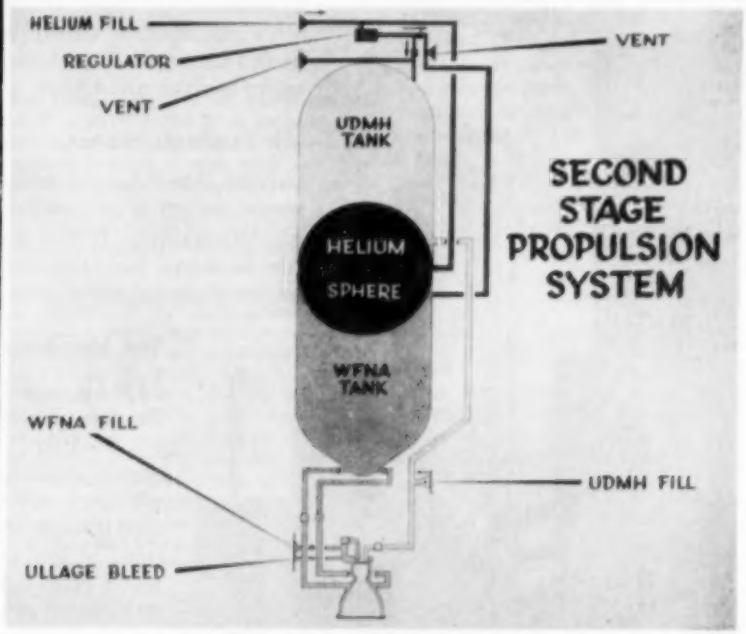
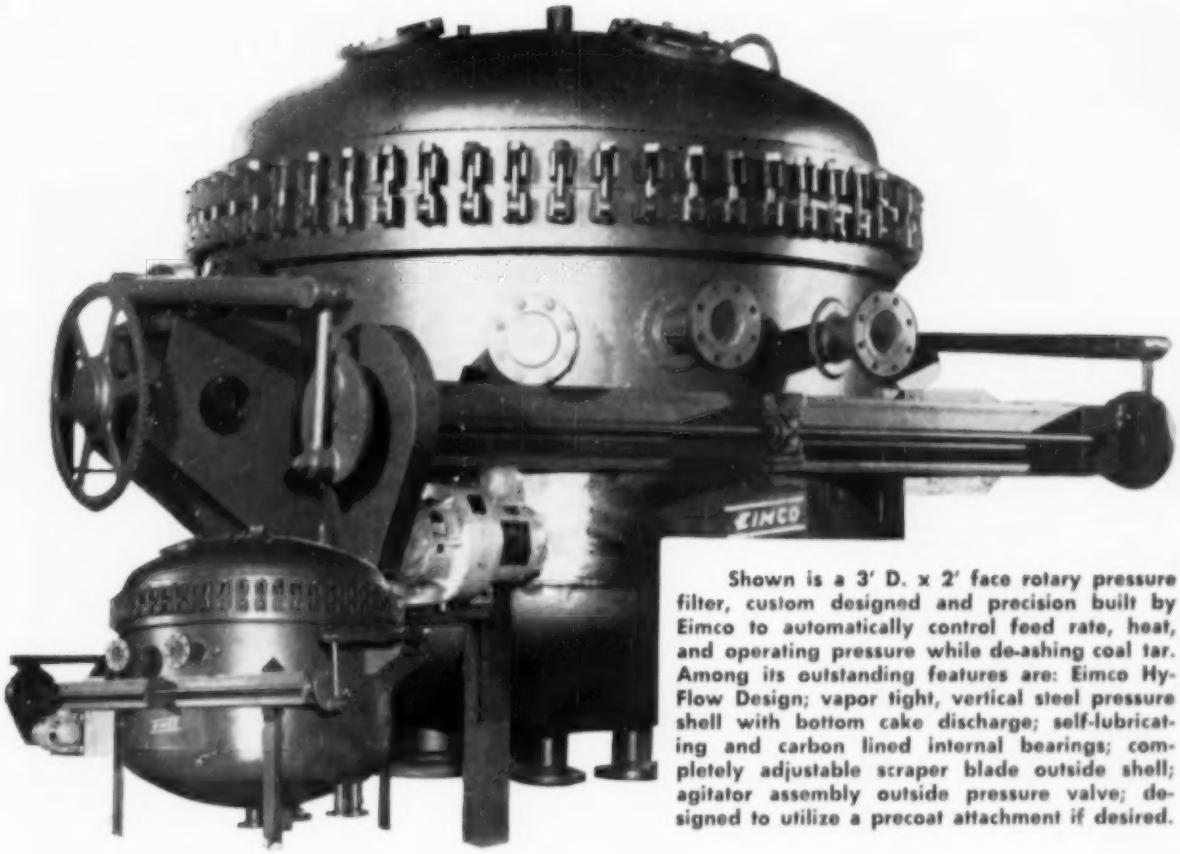


Fig. 2. Schematic diagram of second stage propulsion system.

It is noteworthy that many of these auxiliary systems use sources of energy already available in the rocket, which might otherwise have been wholly or partially wasted, thereby contributing substantial savings in the aeronautical engineer's most precious commodity—weight. These features exemplify the economy of design which is essential to aircraft technology, and which has resulted in Vanguard's remarkably low ratio of empty weight to propellant weight.

(Continued on page 90)



Shown is a 3' D. x 2' face rotary pressure filter, custom designed and precision built by Eimco to automatically control feed rate, heat, and operating pressure while de-ashing coal tar. Among its outstanding features are: Eimco Hy-Flow Design; vapor tight, vertical steel pressure shell with bottom cake discharge; self-lubricating and carbon lined internal bearings; completely adjustable scraper blade outside shell; agitator assembly outside pressure valve; designed to utilize a precoat attachment if desired.

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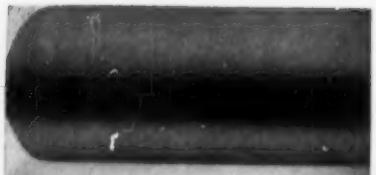

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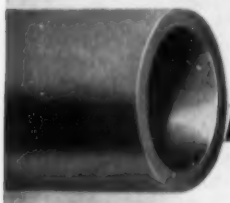

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VANGUARD SATELLITE

(Continued from page 88)

No detailed comment will be devoted to the equipment of the second stage, which contains the "intelligence" of the vehicle: guidance and control systems, telemetering, command receivers, beacons, and electric power supply. The forward structure of the second stage, whose prime function is to provide a housing for the third stage and the satellite, consists of a cylindrical sleeve 32 in. in diameter, topped by a jettisonable nose cone. The sleeve is constructed of a special magnesium-thorium alloy for combined strength and light weight. The nose cone is made in two halves, "clam-shell" style, primarily of a molded asbestos phenolic material, and tipped with solid titanium.

Stage 3

The third stage, except for its satellite payload, is literally a pure propulsion system, without controls of any kind. Since the weight of even the most elementary control system in the third stage would be prohibitive from a performance standpoint, it is stabilized in its course, like conventional ballistic projectiles, by spinning about its longitudinal axis at a nominal rate of 150 rev./min. This is accomplished by mounting the stage on a turntable, which is rotated at the appropriate moment, just prior to second-stage separation, by the tangential impulse of two small "spin rockets" mounted on it. After spin-up, the second stage is decelerated away from the third by two externally mounted "retro rockets." Spin and retro rockets are identical, small (50-lb. thrust) solid propellant motors, designed to Martin specifications and manufactured by the Atlantic Research Corporation.

The spin requirement, among other considerations, dictated the use of a solid propellant for third-stage propulsion, but here the "off-the-shelf" procurement concept broke down completely. Not only was there no rocket in existence in 1955 which would serve the purpose, but the requirements were so far in advance of the then current state of the art that development contracts were actually let to two separate companies selected by a design competition from among all the major solid rocket agencies in the industry. These are the Grand Central Rocket Company, of Redlands, California, and The Allegany Ballistic Laboratory, of Cumberland, Maryland. By virtue of its advanced design, most of the details of this rocket stage must remain classified as secur-

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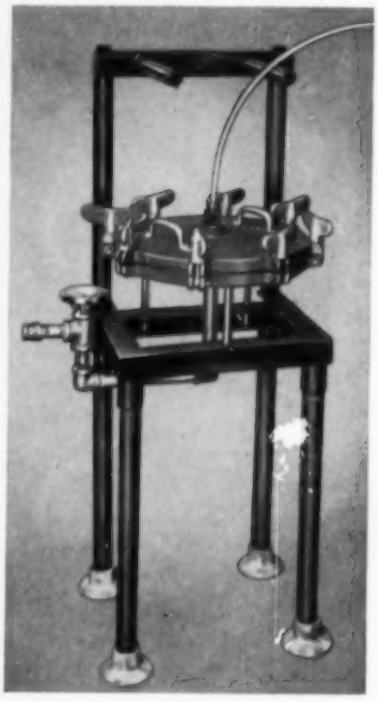

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ity information. Only the following information has been cleared at this time: The rocket is about 5 ft. in over-all length, with a nominal maximum diameter of 18 in. It has a nominal burning time of about 30 sec. and develops an average thrust of about 2,350 lb. Approximately one half of the final horizontal velocity of the satellite will be contributed by the third stage.

With regard to actual propulsion system tests, a great deal has been accomplished to date. Each of the three main propulsion systems has, of course, been subjected to innumerable development, qualification, and acceptance static test firings at the subcontractors' facilities. Full-scale prototypes of the first-stage pressurization system and of each of the major attitude control systems have been tested at The Martin Company. Each vehicle, prior to shipment from Baltimore, is thoroughly checked out in every respect save actual firing of the rockets. At the launching site, Patrick Air Force Base in Florida, all the checkouts are repeated, and the first- and second-stage rockets are static-fired prior to the actual launching.

Testing

The ultimate proof of the design, of course, comes only by flight test. As of this writing (early September, 1957) two test vehicle firings have been attempted and successfully accomplished, with a third scheduled in the near future. The first two test vehicles made use of Martin Viking rockets (the last of an illustrious line) as flying test beds, so to speak, for various Vanguard components. The second of these, at an altitude above 100 miles, successfully spun up and launched a Vanguard third-stage rocket produced by Grand Central, which then proceeded to perform as if it had read the test plan.

The next step in the program will be a small group of test vehicles which incorporate all three live Vanguard stages. As in any such pioneering program, the schedule for these, and for the ultimate satellite launchings, must be allowed considerable flexibility, subject to the degree of success enjoyed in the test firings. The staff at Martin remains completely confident that the Vanguard launching vehicle—and the Vanguard program in general—will attain their primary goal of launching a man-made earth satellite during the International Geophysical Year.

Presented at A.I.Ch.E. meeting, Baltimore, Maryland.

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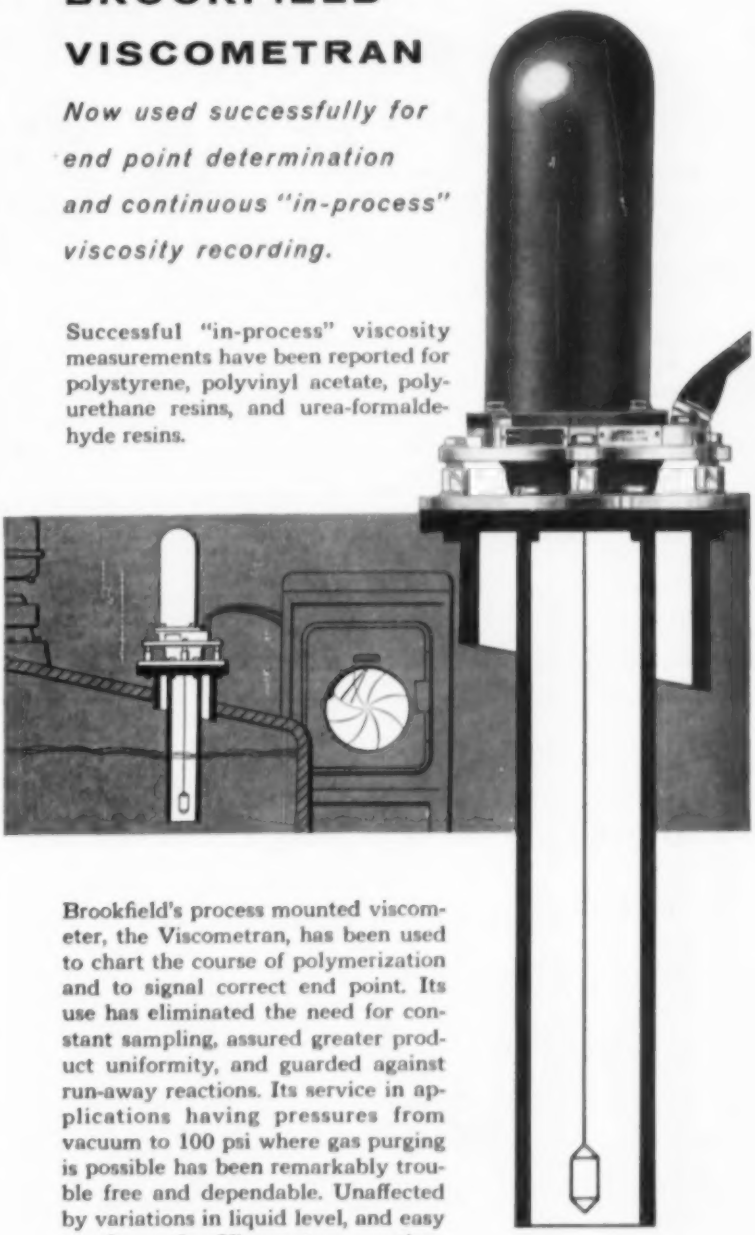

Brookfield's process mounted viscometer, the Viscometran, has been used to chart the course of polymerization and to signal correct end point. Its use has eliminated the need for constant sampling, assured greater product uniformity, and guarded against run-away reactions. Its service in applications having pressures from vacuum to 100 psi where gas purging is possible has been remarkably trouble free and dependable. Unaffected by variations in liquid level, and easy to clean, the Viscometran continuously and accurately senses viscosity — a variable that can very well be fundamental in your process.

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NUCLEAR NEWS

A "Little Geneva" conference on atomic energy was held in September at Columbia University in New York. Designed as a follow-up of part of the Geneva, Switzerland, meeting of 1955, the conclave was attended by more than 150 physicists from thirteen countries, including many from behind the Iron Curtain. President of the five-day conference was I. I. Rabi, Higgins Professor of Physics at Columbia and winner of the Nobel Prize. □

Is the United States following in British footsteps? Speculation is invited by the AEC's recent action in asking industry for proposals to design a gas-cooled, natural-uranium fueled, graphite-moderated nuclear electric power station, capacity 40,000 kilowatts. Closing date for proposals was September 23, 1957. □

The largest aluminum fittings ever forged will help to handle 12,000 to 18,000 gallons per minute of water for cooling purposes at the new AEC research reactor at Oak Ridge. The out-size fittings, supplied by Tube Turns, include reducers 36 inches in diameter, and elbows, returns, and barrel-type tees 24 inches across with walls more than one half inch thick. □

America's largest and most advanced nuclear test facility has gone into operation at the National Reactor Testing Station in Southern Idaho. Chief use of the new facility will be determination of the effects of intense neutron and gamma ray bombardment on material components. The reactor will be operated for the A.E.C. by the Atomic Energy Division of Phillips Petroleum Co. □

A miniaturized atomic energy reactor, designed for school, medical, and industrial laboratories, is in operation at Atomics International. Fueled with uranyl sulfate in water solution, the unit, which operates at a power level of five watts, is only eight feet high and eight feet in diameter, can be installed in almost any existing laboratory without addition of special facilities.

ADVERTISEMENT—*This entire page is a paid advertisement* *Prepared by U. S. Industrial Chemicals Co.*

U.S.I. CHEMICAL NEWS

October ★ A Series for Chemists and Executives of the Solvents and Chemical Consuming Industries ★ 1957

Second U.S.I. Polyethylene Plant Planned for 1958

A second plant to produce U.S.I. PETROTHENE® polyethylene will be built at a new location by National Petro-Chemicals Corporation, majority owned and managed by U.S.I. and minority owned by Panhandle Eastern Pipeline Company.

The new plant, scheduled for operation by late 1958, will produce 75 million pounds-per-year of intermediate density polyethylene resins. Capacity of the present Tuscola, Illinois plant is 100 million pounds-per-year, making the Company's total projected capacity 175 million pounds-per-year.

A modification of the conventional high-pressure process, already proved in the Tuscola plant, will be used in the new installation. Resins produced there will be of an intermediate density type, with properties somewhere between those of the original polyethylenes with which the public is familiar, and the new high-density resins produced by so-called "low-pressure" processes.

Gulf Coast Under Consideration

Site for the new plant has not been chosen. Several Gulf Coast sites are under consideration and the Company has already optioned land at more than one location. The new plant will be constructed in a location other than Tuscola in order to assure customers of a continuing source of supply if production at either location were to be temporarily interrupted. Dual locations will also provide two separate shipping points for PETROTHENE resins, and permit even more rapid delivery to customers in some areas.

Engineering of the new plant has not waited for a final decision on location, however, and this phase of the project is already well underway. M. W. Kellogg Company is handling design and construction of the new plant.

National Petro-Chemicals is already the third largest polyethylene producer in the United States, despite its relatively short history in this field. Petro first entered the field in February, 1955 when its 26 million pound-per-year plant in Tuscola, Illinois came onstream. This was expanded in 1956 to 50 million pounds-per-year, and again in 1957 to 100 million pounds-per-year.

New Feed Supplement for Ruminants Made by U.S.I.

A new, patented liquid feed supplement for cattle and sheep, trademarked MOREA®, will be made by U.S.I. and marketed in most states east of the Mississippi and west of the Continental Divide. U.S.I. will operate under license from Feed Service Corp. of Crete, Nebraska, which developed the product. Feed Service Corp. has been test marketing MOREA in the Midwest for the past several years.

The new supplement accelerates rumen fermentation, enabling cattle and sheep to eat and digest more feed in a shorter time. Dairy animals show improved production. Beef cattle grow faster, produce a higher quality meat than cattle raised by other

MORE

TVA Pilot Plant Demonstrates Fertilizer Formulation with Wet Process Phosphoric Acid

High Analysis Ammonium Phosphate and Ammonium Phosphate-Nitrate Mixtures Can be Granulated Easily And Economically with Continuous Ammoniator

Pilot plant runs, conducted recently by TVA's Office of Chemical Engineering at Wilson Dam, Alabama, demonstrated new methods for making high analysis ammonium phosphate and ammonium phosphate-nitrate granular fertilizers such as 7-28-28, 17-17-17 and 15-15-15. About 400 members of the industry saw the 3-day demonstrations, in which a key role was assigned to wet process phosphoric acid.

Most of the demonstrations were carried out in TVA's continuous ammoniator, in some cases with auxiliary equipment. This type of ammoniator is simple and has found extensive use in industry. It can be employed to make a wide range of grades from a variety of raw materials, including phosphate rock, the superphosphates, and many of the materials produced by U.S.I.—wet process phosphoric acid, anhydrous ammonia, nitrogen solutions, ammonium nitrate, and sulfuric and nitric acids.

Wet process phosphoric acid was used in preparing all ammonium phosphate and ammonium phosphate-nitrate mixtures shown in the table below, which summarizes data published by TVA.

Granulation of a number of grades was accomplished better with wet process acid than with electric furnace acid. Excellent granulation in high nitrogen products was achieved with wet process acid, to which a small amount of iron ore form had been added.

Granules of the products were generally spherical and quite hard. Bag-storage and open bin bulk-storage test results were favorable.

Wet Process Acid Economical

Also of prime interest at the demonstrations were studies prepared by TVA indicating that high analysis granular mixtures made with wet process phosphoric acid may be produced at lower cost than conventional fertilizers. This was shown specifically for several grades, using raw materials costs believed typical for a midwestern location.

Other highlights of the demonstrations included manufacture of high analysis mixed goods using diammonium phosphate, superphosphoric acid, and electric furnace phosphoric acid; manufacture of nitric acid phosphates, granular normal superphosphate, granular triple superphosphate, granular enriched superphosphate, and granular no-nitrogen grades.

TVA FORMULATIONS FOR AMMONIUM PHOSPHATE, AND AMMONIUM PHOSPHATE-NITRATE FERTILIZERS UTILIZING WET PROCESS PHOSPHORIC ACID

Material	Grade	17-17-17	15-15-15	11-22-22	16-48-0	8-16-32	7-28-28
Phosphoric Acid, Wet Process	75% H_3PO_4	625	425	809	1767	589	1031
Ammoniating Solution *	–	826 (Z-7)	481 (Z-7)	541 (X)	242 (X)	362 (X-6)	–
Anhydrous Ammonia	–	–	–	–	275	–	173
Ammonium Sulfate	20.5% N	–	500	–	–	–	–
Sulfuric Acid	93% H_2SO_4	112	–	–	–	–	–
Potassium Chloride	60% K_2O	567	500	733	–	1067	933
Concentrated Superphosphate	46% P_2O_5	–	150	–	–	–	–
Iron Ore	–	–	–	–	–	20	–
Filler	–	–	–	51	–	–	–
Conditioner	–	44	53	80	88	84	52
Recycle	–	4500	2000	2500	7000	1500	2000

*** COMPOSITION OF AMMONIATING SOLUTIONS, %**

(U.S.I. Designation)	TVA Designation	Free Ammonia	Ammonium Nitrate	Ammonium Carbamate	Water	Total N
(1)	X	22.2	65.0	0	12.8	41.0
(10)	X-6	25.0	69.0	0	6.0	44.8
(2)	Y	26.2	55.5	0	18.3	41.0
(12)	Z-7	19.0	74.0	0	7.0	41.4

CONTINUED ***Supplement***

feeding methods (more marbling with less waste fat).

MOREA is a liquid mixture containing urea, ethanol, phosphoric acid, essential trace minerals and molasses. U.S.I. will sell a concentrated liquid MOREA premix to feed manufacturers who will blend the concentrate with molasses. The company is currently appointing manufacturers who will mix and distribute the final MOREA product to feeders. U.S.I. is a basic producer of ethanol and phosphoric acid which are both in the premix.

X-rays Measure Hafnium In Zirconium Samples

Small amounts of hafnium in zirconium samples can be determined by means of X-ray fluorescence, according to two members of the Faculty of Science of Paris. After a sample is bombarded with X-rays, an aluminum monocrystal and a Geiger counter measure the intensity of the resulting characteristic spectrum of hafnium.

More precise measurements may be obtained by monitoring part of the beam from the X-ray tube with a tantalum sample and an auxiliary counter. A hafnium content of about 0.016% can be detected in this way.

Come to the "Atomfair"

The 1957 Trade Fair of the Atomic Industry is being held at the New York Coliseum from October 28-31. The Fair is being staged in conjunction with the Atomic Industrial Forum's annual atomic industry conference; the Winter meeting of the American Nuclear Society; the first major unclassified Reactor Safety Conference; the second conference on Careers in Nuclear Science & Engineering; and the annual meeting of the Professional Group on Nuclear Science of the Institute of Radio Engineers.

Look for U.S.I. in Booths 117-118.

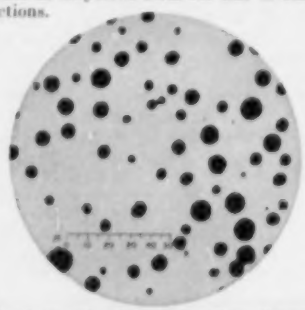
Sodium Dispersions May Be Key to Lower Cost Acetylacetone Production

The use of sodium dispersions as a catalyst for production of acetylacetone may permit substantial reductions in production costs, according to recently reported experimental work. Yields are higher, and reaction time much shorter, than with processes using sodium alkoxide or small pieces of metallic sodium. Also, the hazards involved in producing acetylacetone by the sodium alkoxide route are minimized when sodium dispersions are used.

In the experiments reported, sodium dispersions in toluene and xylene were added to mixtures of acetone and methyl acetate with the medium-boiling hydrocarbons as diluents. The dispersion samples used were obtained from U.S.I. The reaction was carefully controlled. Acetic acid and ethyl acetate were used to separate and extract the acetylacetone. On distillation under vacuum, a water-white, acid-free acetylacetone of 97 to 99% purity was obtained.

Total reaction time was about two hours, as compared with 24 hours with small pieces of sodium and 40 to 50 hours with sodium alkoxide.

A recently published 42 page booklet entitled "Sodium Dispersions" is available from U.S.I. to those interested in using sodium in dispersed form for this or similar reactions.



Photomicrograph of typical sodium dispersion, with most particles of 2-15 microns diameter.

TECHNICAL DEVELOPMENTS

Information about manufacturers of these items may be obtained by writing U. S. I.

A new polyvinyl acetate resin emulsion adhesive, compatible with dextrine adhesives, is designed for high-speed case and carton sealing. Adhesives can be changed without shutting down machine to clean glue box. **No. 1281**

Proteins and amino acids in animal nutrition are discussed in detail in a revised, up-to-date booklet. Included are such subjects as Mutual Supplementary Action of Proteins; Relation of Amino Acid Requirements to Protein Level. **No. 1282**

Electronically heat-sealable vinyl gravure inks in a wide range of colors are currently being produced. Prints for automotive upholstery have been heat-sealed without destructive arcing sometimes found in conventional inks. **No. 1283**

An atomic reactor is being made with a polyethylene moderator. Can be used for applied research, radiation testing, a wide range of educational purposes — such as training of reactor operators. Said to be versatile, inexpensive. **No. 1284**

A differential pressure liquid level transmitter mounted directly on a tank nozzle measures viscous or slurry-type liquids in open or closed vessels. It uses a force balance principle, can operate a remote indicator or recorder. **No. 1285**

A bright new B-O-N type red pigment has a bluish shade, good light and bleed resistance. Can be used alone or with other colors for a variety of shades. Said to be lower in cost, easier to grind. **No. 1286**

Polyethylene ware for laboratories and clinics is described in a new 8-page bulletin. Items available include beakers, aspirator bottles, tubing, pipet-fillers, vials, carboys. **No. 1287**

A new synthetic gum is said to be an excellent binder that dissolves in water or alcohol to give non-viscous solutions, even in high concentrations. Requires no preservative, being self-active as bactericide or germicide. **No. 1288**

A new hydrophobic lanolin derivative with good solubility and solubilizing properties is said to be valuable for aerosols, shampoos, suntan and sunscreen preparations, and powders and talcs. **No. 1289**

Fire extinguishers are described in a new buyers guide. Information is given on dimensions, discharge ranges, laboratory approvals and classifications, and other construction data for portable fire-protection equipment. **No. 1290**

PRODUCTS OF U.S.I.

INORGANIC CHEMICALS:

Sodium, Metallic: cast solid in tank cars, steel drums, pails, bricks in barrels, pails.
Chlorine: liquid, in tank cars.
Caustic Soda: 50% liquid, in tank cars.
Sodium Peroxide: dust-free granules, in drums.
Sodium Sulfate
Sulfuric Acid: all strengths, 60° Baumé to 40% Oleum. Also Electrolytic grade to Federal specifications. Tank cars or tank wagons.
Phosphatic Fertilizer Solution (Wet Process Phosphoric Acid)
Ammonia: Anhydrous, commercial and refrigeration. Tank cars or tank wagons.
Nitrogen Fertilizer Solutions
Ammonium Nitrate: 33%

OTHER PRODUCTS:

Alcohols: Ethyl (pure and all denatured formulas), Normal Butyl, Amyl, Fusel Oil; Proprietary Denatured Alcohol Solvents SOLOX®, PILMEX®, ANSOL® M, ANSOL® PR.

PETROTHENE® Polyethylene Resins.
Esters, Ethers and Ketones: Normal Butyl Acetate, Dibutyl Phthalate, Diethyl Carbonate, Diethyl Oxalate, Ethyl Acetate, Ethyl Ether, Acetone, Diatol®.
Intermediates and Fine Chemicals: Acetoacetarylides, Dimethyl Hydrazine, Ethyl Acetoacetate, Ethyl Benzoylacetate, Ethyl Chloroformate, Ethylene, Ethyl Chloride, Ethyl Sodium Oxalacetate, U.S.I. ISOSEBACIC® Acid, Methyl Hydrazine, Sodium Ethylate Solution, Triethyl Aluminum, Trimethyl Aluminum, Urethon USP (Ethyl Carbamate).
Animal Food Products: Calcium Pantothenate, Choline Chloride Products, Curbay B-G® 80, Special Liquid Curbay®, DL-Methionine, Niacin USP, Riboflavin Concentrates, Vitamin B_{12} and Antibiotic Feed Supplements, Vacatone® 40, Vitamin D_3 and K_3 Products, Antioxidant (BHT) Products, Special Mixes, U.S.I. Permadry Products (Sealed-In Vitamin A).
Pharmaceutical Products: DL-Methionine, N-Acetyl-DL-Methionine, Riboflavin USP, Urethon USP, Intermediates.
Metals: Titanium Sponge, Zirconium Sponge, Zirconium Platelets, Hafnium Oxide, Hafnium Sponge.

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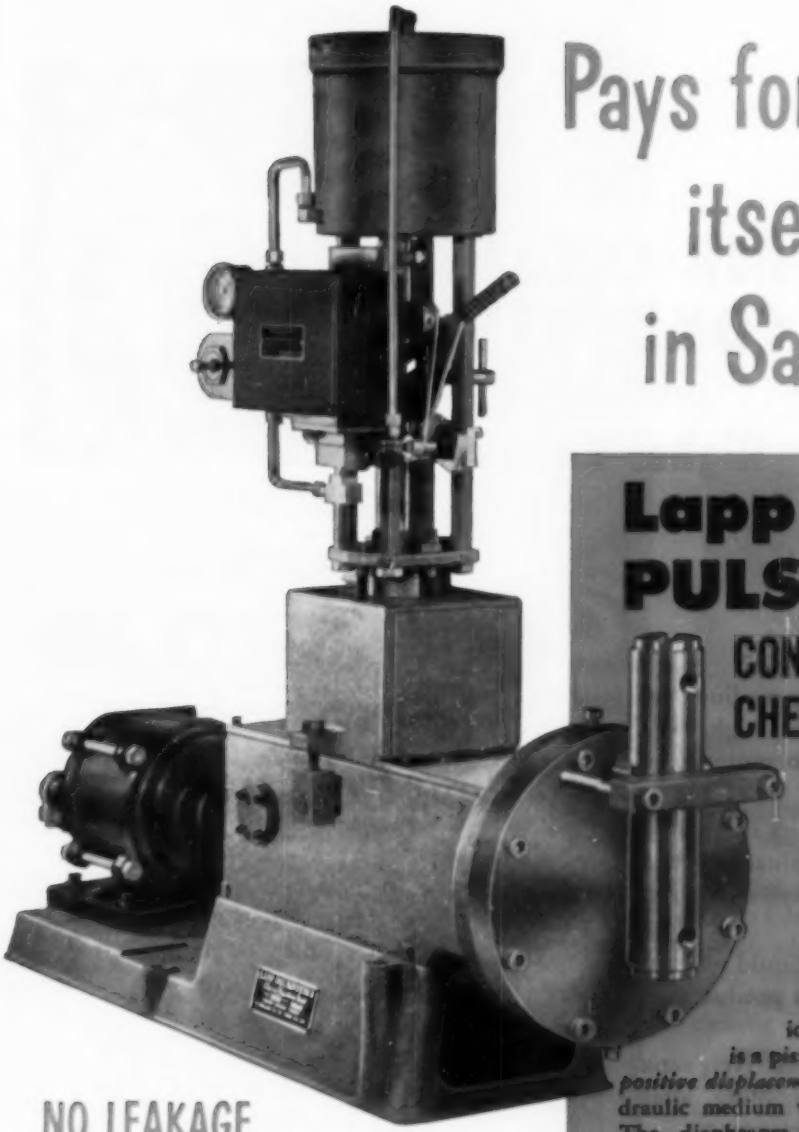

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WRITE FOR BULLETIN 440 *with typical applications, flow charts, description and specification of models of various capacities and constructions. Inquiry Data Sheet included from which we can make specific engineering recommendation for your processing requirement. Write Lapp Insulator Co., Inc., Process Equipment Div., 289 Poplar St., Le Roy, N. Y.*

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● Using air as the cooling medium, the Niagara *Aero* Vapor Condenser produces a higher vacuum than other type condensers, and with more economy of power and steam.

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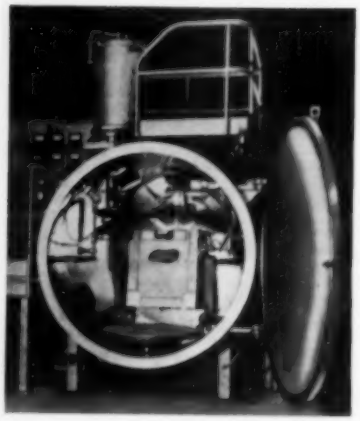
NUCLEAR NEWS



First commercial-scale production of pure beryllium, essential material in the construction of nuclear reactors, is underway at the recently-started-up plant of the Beryllium Corp. near Hazleton, Pa. Entire output of the plant will go to AEC—price: approximately $47 per pound.

Key production unit is an induction-heated vacuum melting and refining furnace. The furnace, built by F. J. Stokes Corp., has a melting and refining crucible with a capacity of 120 pounds of beryllium, which is charged in the form of shot. Melting and refining are carried out at a pressure of about 10 microns. A large bulk additions system, operating through a vacuum lock, permits recharging of the crucible without breaking the vacuum inside the furnace shell. The Lummus Co. engineered and built the plant.

Alco Products, Inc. has been commissioned to build three intermediate sodium heat exchangers for the $54,000,000 Enrico Fermi nuclear electric generating station near Detroit. Each of the three units will be approximately 6 feet in diameter, 30 feet long, and will weigh about 124,000 pounds. Design of the exchangers is said to incorporate features first used in units made by Alco for the nation's first nuclear submarine, the Nautilus. Cost of the exchangers will be in excess of $1,750,000.

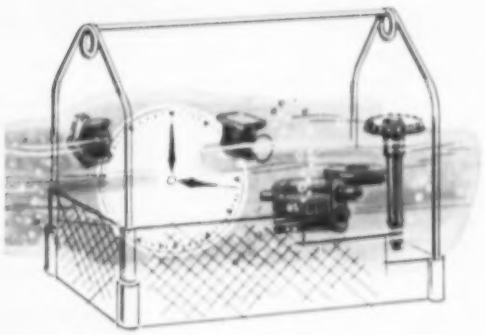
In the sodium-cooled system, the exchangers will transfer heat from the primary sodium stream to the secondary sodium stream, the heat being transferred to three steam generators. Each of the stainless steel, concrete-shielded exchangers will have a capacity of 500 million B.t.u.

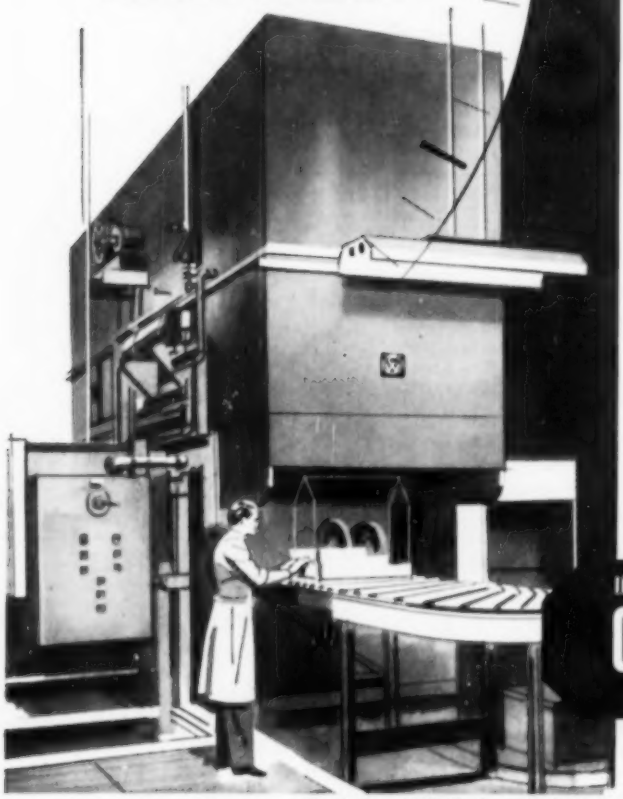
First nuclear fission reaction in Latin America took place when the Institute of Nuclear Energy's new research reactor in Sao Paulo, Brazil, went critical recently. The "swimming pool" reactor is rated at 5,000 kilowatts, is fueled with 20 per cent enriched uranium. Designers and builders of the unit were Babcock & Wilcox. □

Curtiss-Wright

Ultrasonic Degreaser

cleans the hundreds of parts of an aircraft engine in minutes instead of hours





Ultrasonics — the science of high frequency vibrations — is today revolutionizing cleaning techniques in aircraft powerplant production. A new Curtiss-Wright Ultrasonic Degreaser — developed by the Industrial and Scientific Products Division — is now cleaning 95% of all precision parts of the powerful Curtiss-Wright Turbo Compound engines.

This job used to take half a day per engine using ordinary cleaning methods. Now it takes less than an hour — and provides superior cleaning as well as important cost-savings.

Ultrasonic cleaning drives out grease and dirt from all surfaces of the part, even from small and intricate assemblies, and is equally effective on such parts as large machine castings. Its techniques can be custom-suited to many types of industrial production. Write for details on the complete line of Curtiss-Wright cleaning and washing equipment.

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The electronic "tail" wags the process

"The chemical process control of the future will be effected not by control of the quantity and composition of the streams entering the process, but directly by the purity and uniformity of the product."—*Gordon S. Brown, M.I.T.*

Fifty million dollars worth of electronic process control instruments were recently exhibited under one roof at the Instrument-Automation Conference and Exhibit of the Instrument Society of America in Cleveland. Represented in the show, and discussed in the lecture programs, was evidence of fantastic progress being made in the perfection of computing equipment capable of receiving process data continuously, of making the necessary calculations almost instantaneously, and of transmitting the proper control instructions to the electronic control system. Computing instruments are claimed by some manufacturers to be ready to close the loop and to run plants on a continuous basis.

But is the loop ready to be closed? Are the information collecting and conversion devices ready to supply the computer? Again, judging from the variety and complexity of the exhibits at Cleveland, there is considerable evidence of the existence of a large supply of instruments which can analyze continuously and precisely raw material, process, and product streams consisting of many components, and which can transmit this information continuously to the central control system.

Is America "Hardware Happy?"

At Cleveland there was evident a widespread feeling among leading "systems" engineers that the United States is short on basic thinking in the process control field, that we have gone all out in the development of instruments which, in many cases, are unnecessarily complicated for the job in hand. Certain experts state that some of the European countries, particularly Western Germany, are forging ahead in the elucidation of basic principles and in the construction of simpler but equally effective instruments.

In effect, the computer experts and the instrument makers appear now to be saying to the chemical engineer, "Just show us where to install our devices in your process, and automatic control will be a reality."

Knowing where to spot these control points, and what to deduce from the type of analytical data obtained, appears to be the present dilemma of all those close to the process, particularly the chemical engineer. Said Gordon S. Brown of M.I.T., who represented the servo function at this meeting: "In many cases, not enough is known about the basic properties of matter, about molecular structure, to enable the selection of proper parameters for effective process control." Brown believes that the selection of sampling points and the perfection of sampling techniques are the all-important steps to be worked out in the present situation. This view was also voiced by W. A. Crawford of DuPont's Design Division when he said "the major obstacles to instrumentation now lie within the process itself and not in the instruments." He went on to emphasize that, contrary to certain recently publicized statements, there are still problems of measurement for which no satisfactory solution has yet been found. For example, flow meas-

(*Continued on page* 100)

WHAT'S COOKING IN THE DEEP FREEZE?

With little fanfare or publicity, the National Bureau of Standards has for the last year been spearheading a major research program aimed at developing "the art of freezing free radicals and atoms."

The roster of chemical and petrochemical companies which have assigned top-flight research personnel to assist NBS people in Washington on free radical research reads like a Who's Who of the American chemical industry—Dow, California Research, Ethyl, Monsanto, Callery, Wyandotte, National Distillers, Humble, Koppers, Union Carbide, Olin Mathieson, General Electric, Standard of Indiana.

Why the pronounced industrial interest in free radicals, up to now a subject of concern only to fundamental research scientists? What possibilities do the great chemical companies see in their respective crystal balls? The answer began to be apparent at the recent Symposium on the Formation and Stabilization of Free Radicals held at the National Bureau of Standards in Washington.

"Analysis indicates that significant increases in the performance of rocket propellants are possible if certain types of free radicals and atoms could be utilized." So said George Moe of Aerojet-General Corp., speaking on "Research on Free Radicals as Rocket Fuels." Whereas the maximum specific impulse * to be expected from ordinary chemical propellant systems is in the range of 350 to 400, it can be calculated that the introduction of free radicals such as NH, CH, or atomic H into a suitable working fluid could result in specific impulses well in excess of 400.

(*Continued on page* 101)

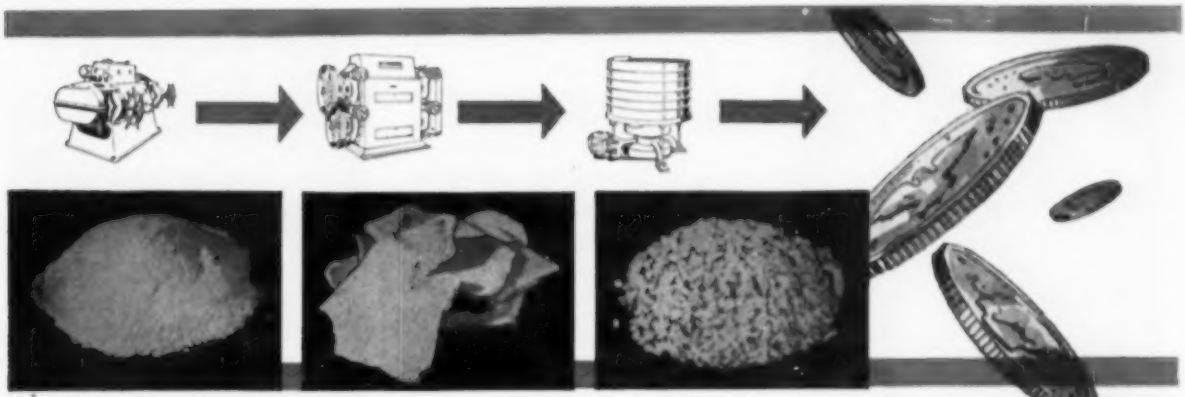
* Specific impulse of a fuel and oxidizer mixture is defined as pounds of thrust obtained from the reaction of 1 lb./sec. Units are therefore lb./lb./sec.

HEAT TRANSFER CONFERENCE DRAWS TOP EXPERTS

The Heat Transfer Conference, jointly sponsored by A.I.Ch.E. and A.S.M.E. and held in August at Penn State University, was a "fundamental" success, according to various participants. A new unified theory of boiling which may within two years be a practical design method, plus reports reflecting more sensitive measurement of velocity data as related to temperature distribution in tubes, were two of the principal subject areas under wide comment and discussion.

The story behind the new unified theory of boiling is one of international cooperation, or competition, rivalling some of the more exciting mystery tales. Original stimulus arose from the USSR, when a scientist named Kutateladze published in 1951 "A Hydrodynamic Theory of Changes in the Boiling Process under Free Convection Conditions." In this, he postulated that bubble formation from an immersed heated surface can be lik-

(*Continued on page* 101)



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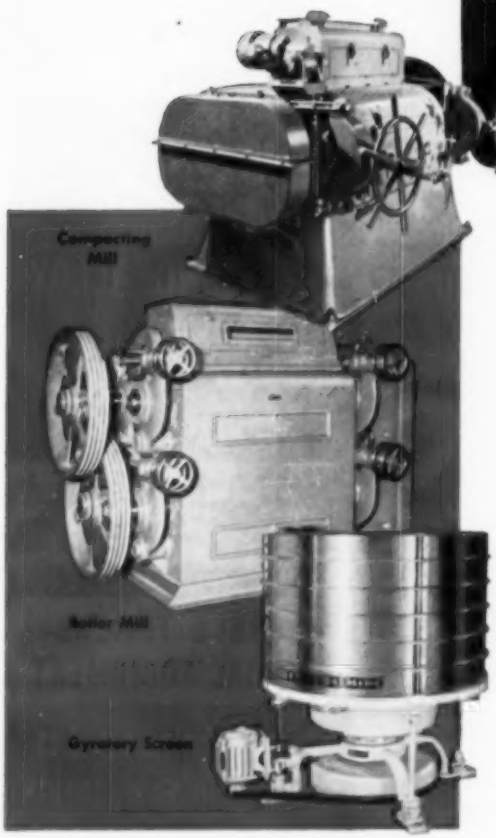

You start with a pile of practically worthless material and wind up with a profit! Magic? Well, hardly — unless you want to call the mechanical efficiency of the Allis-Chalmers Process System magic.

How It Works

In a recent installation the conversion starts with an unusable, unacceptable minus 30 mesh chemical salt . . . fines created in the original process. An Allis-Chalmers compacting mill densifies these fines into flakes or slabs. Flakes are granulated in an Allis-Chalmers roller mill. Final separation is made in an Allis-Chalmers stainless steel gyratory screen. Result — 70 to 80% recovery of salable product. What's more — the resulting granules equal or surpass the natural product in every respect.

The entire system is mechanical; therefore, it's more economical than controlled crystal growth.

For More Information

Get the complete story from your A-C representative or write Allis-Chalmers, Industrial Equipment Division, Milwaukee 1, Wisconsin. Ask for Bulletin 25C6177J.

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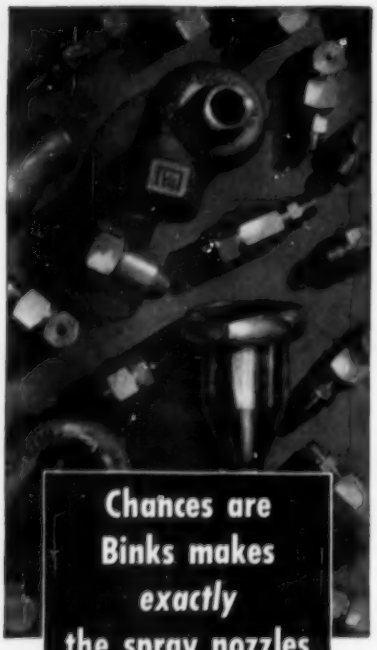

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(Continued from page 98)

urements on slurries are generally extremely unreliable. "If," said Crawford, "your flow measurement is in error by 15 per cent, five decimal point accuracy in a computer will be of no avail."

Brown is far from pessimistic about the present bottleneck. "It has been the history of scientific progress," he said, "that all machines are soon asked to do more than they were originally designed for."

Today, said Brown, the electronic "tail" seems rather to be wagging the process. The perfection of fantastically complicated and efficient instruments and computers is starting to exert irresistible pressure on the process industries. For the chemical engineer, the hour is already late, compared to progress made in many other branches of industry.

Something New in Chemical Engineering

A top executive of a large oil company thinks that revolutionary changes in systems engineering training of chemical engineers are in the cards. Traditionally, he says, we have been trained to think in terms of static or steady-state systems. The material balance was a primary design factor. The approach to automatic control changes this, however. Now, dynamic analysis, dependent on a profound knowledge of the kinetics of the process steps, must be employed. New types of pilot plants, in which time lags are held to a minimum, will be the basis for full-scale plants which will be much more amenable to automatic control than present plants in which long time lags exist.

Changing Educational Scene?

The combination of reaction kinetics with the use of machine calculation methods drives home the point that the chemical engineer of the future must lean heavily on the physical chemist and the pure mathematician, as well as on the electrical engineer and the electronics expert. Since a really comprehensive knowledge of all these disparate fields is obviously beyond the reach of the ordinary practicing chemical engineer, the only answer seems to be closer liaison between the various engineering sciences. Brown of M.I.T. states that a start is being made in this direction, notably at the University of California and at M.I.T. However, he emphasizes, the approach must permeate all of the chemical processing industry—the educational system can't do the whole job.

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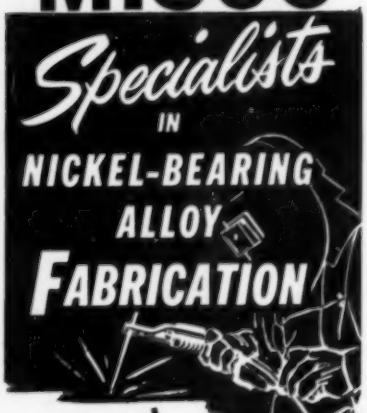

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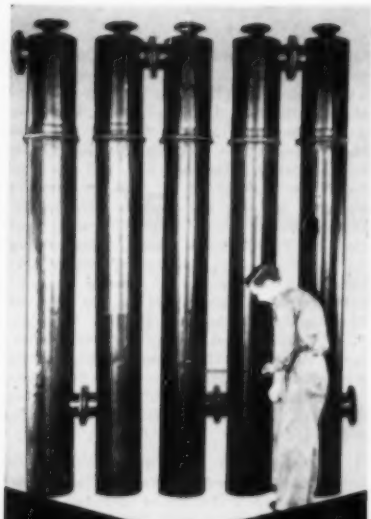

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HEAT TRANSFER

(*Continued from page 98*)

ened to wave phenomena and predictably analyzed by appropriate mathematical techniques. In an attempt to confirm or deny the theory, Prof. Yan Po Chang of Tai Pai University, Formosa, studied the high speed photographs of boiling taken by J. W. Westwater of Illinois University. Chang found the wave formation, and pointed out that the waves fitted the theoretical formulas in Lamb's thermodynamics. Next, H. Zuber, a young east-European with hair-raising wartime experiences in resistance forces behind what is now the Iron Curtain, worked out a relationship between these basic ideas of wave stability and the burnout characteristics experienced in practical boiling heat transfer installations. Among the highlights of the Conference were Westwater's showing of his latest high-speed photographs, and Zuber's presentation of his new correlations. Thus, there is developing what may be a whole new area for fundamental research, and new design equations to permit much closer approach to burnout thresholds.

CEP's thanks are due Prof. Myron Tribus of U.C.L.A., who was publicity chairman for the Conference, and through whose efforts the above report was made possible.

DEEP FREEZE

(*Continued from page 98*)

Executives of several oil companies present at the Washington meeting indicated "off the record" that free radical technology may also result in startling innovations in the field of more conventional fuels—even for ordinary automotive engines.

How to Trap Free Radicals

Experimental work at NBS has thus far involved production of free radicals by such diverse techniques as photolysis, electric discharges, electron bombardment, and gamma irradiation. The free radicals so found are suddenly trapped at extremely low temperatures, in most cases below 77° K. Some species can be stored in an inactive state indefinitely at these temperatures. The complexity of the subject can be illustrated by a consideration of the various types of equipment being used for detecting and estimating concentrations of free radicals —X-ray diffraction, electron diffraction, paramagnetic resonance absorption, optical emission and absorption, mass spectroscopy, magnetic susceptibility, calorimetry, and chemical reactions. —*W. H.*

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Chicago's skyline from Lake Michigan. In foreground, Grant Park. To left, Conrad Hilton hotel; to right, new Prudential building.

FUTURE MEETINGS

MEETINGS **SYMPOSIA**

■ **WASHINGTON, D.C.**

November 4-6, 1957. **International Symposium on Saline Water Conversion,** sponsored by Office of Saline Water, National Academy of Sciences, and National Research Council.

■ **HOUSTON, TEXAS**

November 20 and 21, 1957. Shamrock Hilton Hotel. Joint Meeting of Commercial Chemical Development Association and Chemical Market Research Association. Theme of meeting will be "The Gulf Coast Chemical Industry in 1965—a Forecast."

■ **CHICAGO, ILL.**

December 8-11, 1957. Conrad Hilton Hotel. Annual Meeting, A.I.Ch.E. For full program details see page —.

■ **1958 MEETINGS**

• Chicago, Ill., March 17-21, 1958. 1958 Nuclear Congress. Managed by A.I.Ch.E. Coordinated by E.J.C. Will include: 4th Nuclear Engineering and Science Conference, 4th International Atomic Exposition, 6th Atomic Energy in Industry Conference, 6th Hot Laboratories and Equipment Conference, and the American Power Conference.

• Montreal, Canada, April 20-23, 1958. Sheraton-Royal Hotel. Joint A.I.Ch.E.-C.I.C. Conference. A.I.Ch.E. CHAIRMAN: **Kenneth Beatty,** North Carolina State College, Raleigh, N. C. CO-CHAIRMAN: **W. H. Gauvin,** McGill University, Montreal. **Chemical Engineering Aspects of Heavy Water Power Reactors**—CHAIRMAN: Donald Stuart, Evaluation Section, Civilian Power Reactors Branch, A.E.C., Washington 25, D. C. CO-CHAIRMAN: W. M. Campbell, Canadian A.E.C. **Chemical Engineering Methods in Mineral Processing**—CHAIRMAN—F. A. Forward, University of British Columbia, Department of Mining & Metallurgy, Vancouver 8, B. C. **Fluid Mechanics**—CHAIRMAN: S. G. Mason, Dept. of Chemistry, McGill Univ., Montreal, P. Q. **Noise in the Chemical Industry**—CHAIRMAN: G. Thiessen, Physics Division, National Research Council, Ottawa, Ontario. **Chemical Engineering Technology in the Pulp and Paper Industry**—CHAIRMAN: L. R. Thiesmeyer, Pulp and Paper Research Institute of Canada, 3420 Univ. St., Montreal, P. Q. **Future Sources of Energy**—CHAIRMAN: J. W. Hodgins, Director of Engineering Studies, Hamilton College, McMaster Univ., Hamilton, Ontario. **Modern Chemical Plant Construction Techniques**—CHAIRMAN: S. A. Guerrieri, Lummus Co., 385 Madison Ave., New York 17, N. Y. **High Temperature Materials for Jets and Rockets**—CHAIRMAN: Charles Marsel, New York University, New York, N. Y. **Statistics in Chemical Engineering**—CHAIRMAN: J. C. Whitwell, Princeton University, Princeton, N. J. **General Papers**—CHAIRMAN (pro tem): W. H. Gauvin, Dept. of Chemical Engineering, McGill Univ., Montreal, P. Q. Special panel discussion (Sunday afternoon, April 20, 1958)—**Chemical Engineering Education in the United States and in Canada**—MODERATOR: W. G. Whitman, Dept. of Chemical Engineering, M.I.T., Cambridge, Mass.

• Namur, Belgium, June 10-13, 1958. **First International Congress on Vacuum Techniques,** sponsored by Commissariat General of the Belgian Government with the Brussels 1958 International and Universal Exhibition. Further information from Professor E. Thomas, c/o CSN/ERM, 30, Avenue de la Renaissance, Brussels 4, Belgium.

• Berkely, California, June 19-21, 1958. Dwinelle Hall, University of California. **1958 Heat Transfer and Fluid Mechanics Institute.** Sponsored by Calif. Institute of Tech., Stanford Univ., University of Calif., Univ. of Santa Clara, Univ. of Southern Calif., A.I.Ch.E., Amer. Rocket Society, A.S.M.E., Amer. Society of Refrigerating Engineers, Institute of Aeronautical Sciences, Society of Automotive Engineers. Papers invited on fundamental aspects of heat transfer and fluid mechanics. Titles and abstracts to be submitted by No-

(Continued on page 110)

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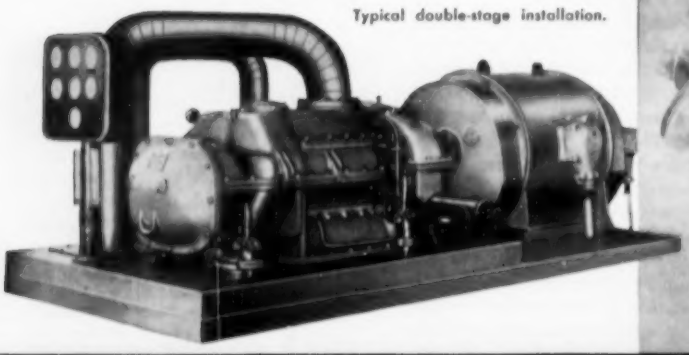

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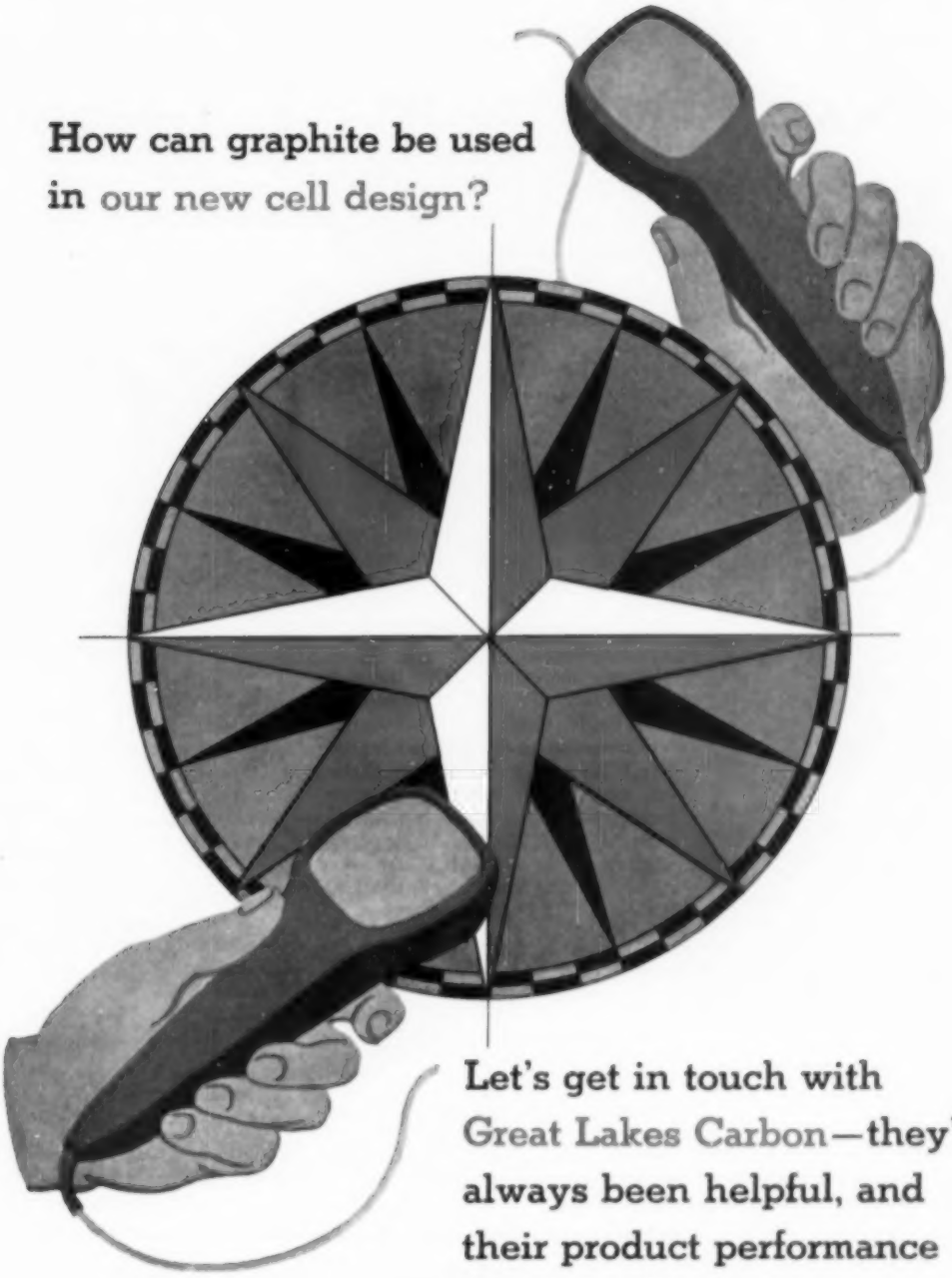

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IS THERE A DELAY IN DEVELOPMENT OF PROCESSES FOR

FRESH WATER FROM SALINE?

Research and development on processes for de-salting saline water are proceeding—but not at the rate hoped for by many who expected rapid action under Congress' $10 million authorization bill of 1952.

Joseph L. Gillman, Jr.

There is now a sharp difference on the water problem between Congress' "get it now and never mind the cost" and the "get it right and save money even if it takes time" view which is apparently the official view of the Interior Dept.'s Office of Saline Water.

As a solvent, as a heat transfer agent, etc., the mainstay of the process industries is water—and water is becoming so short in supply that Congress is alarmed. Even though we use only some 13 per cent of the total fresh water rained upon us, the usable supply is rapidly becoming critically short—particularly in new, rapidly growing industrial areas.

It was in 1952, when the need for water became acute in the new industrial and arid areas of the Southern California coast, that the Government decided to investigate seriously the possibility of de-salting sea water. In the meantime, interest of commercial firms has been heightened by the immediate promise of higher rewards by solving the traditional fresh water shortage of the oil-rich middle eastern countries.

An Economical Process

The problem does not lie alone with developing a new means for effecting the separation of sea-salt from water. This process has been successfully carried on for years on a multi-million-gallon-per day basis by such non-profit organizations as the United States Navy. The real problem lies in effecting the separation at a price competitive with nature's gigantic solar evaporation system—a tough job even for dollar-conscious chemical engineers.

At about the time it was becoming apparent that the more direct means of procuring fresh water by "rain-making" and by long distance transportation would not promptly and economically provide the necessary permanent relief, the Saline Water Act of 1952 was passed. The act was administered by the Bureau of Reclamation until October 8, 1953, when the work was transferred to the Office of the Secretary of the Interior. It was not until September 16, 1955 that the Office of Saline Water under its present director, David S. Jenkins, was organized.

On January 3, 1956, the then Secretary of the Interior, Douglas McKay, submitted a fairly optimistic 78-page report on the progress of the Office of Saline Water to the President and the Congress, and a year later, on January 11, 1957, Secretary of the Interior Fred A. Seaton submitted a 17-page less detailed report.

Shortly thereafter, under the date of February 27, 1957, Congressman Clair Engle, California, Chairman of the Committee on Interior and Insular Affairs and author of the Saline Water Act, addressed a letter to Assistant Secretary of the Interior Fred G. Aandahl, under whose direct cognizance the Office of Saline Water operates, requesting a hearing, in which he stated:

". . . recent reports do not indicate the progress hoped for. Several on the committee have expressed disappointment. There appears to be a feeling that the program is not receiving the degree of urgency it deserves or which the Congress expected."

During Interior vs. Congress hearings on March 7 and 8, 1957, Director Jenkins summarized his presentation to the Committee as follows:

". . . in the 5 years that we have been working, with $2,000,000 spent so far, or about one eight-thousandths of the amount, which I understand is about $16,000,000,000, that has been spent on atomic energy, we feel that we have made some progress. That progress can be summed up as follows:

1. The field of processes has been reduced from 19 general groups to 6.
2. Four processes have been advanced to the pilot-plant stage.
3. There have been several processes which have been advanced to the engineering stage.
4. There have been developed 3 wholly new principles to separate salt water, all of which are expected to reach the engineering stage in 1 or 2 years.
5. Work has been initiated on two wholly new principles.
6. We are now initiating and planning to begin in July, active exploration, possibly in cooperation with AEC, of combinations of atomic energy and salt water conversion.
7. There has been stimulated a very significant number of private investigations by private firms.
8. We are cooperating with a large number of foreign countries; and I believe there has been a great deal of goodwill generated."

In a report on the hearings (dated April, 1957), the Committee expressed disappointment at the progress revealed by the hearings as indicated in these excerpts:

"The committee's experience in analyz-

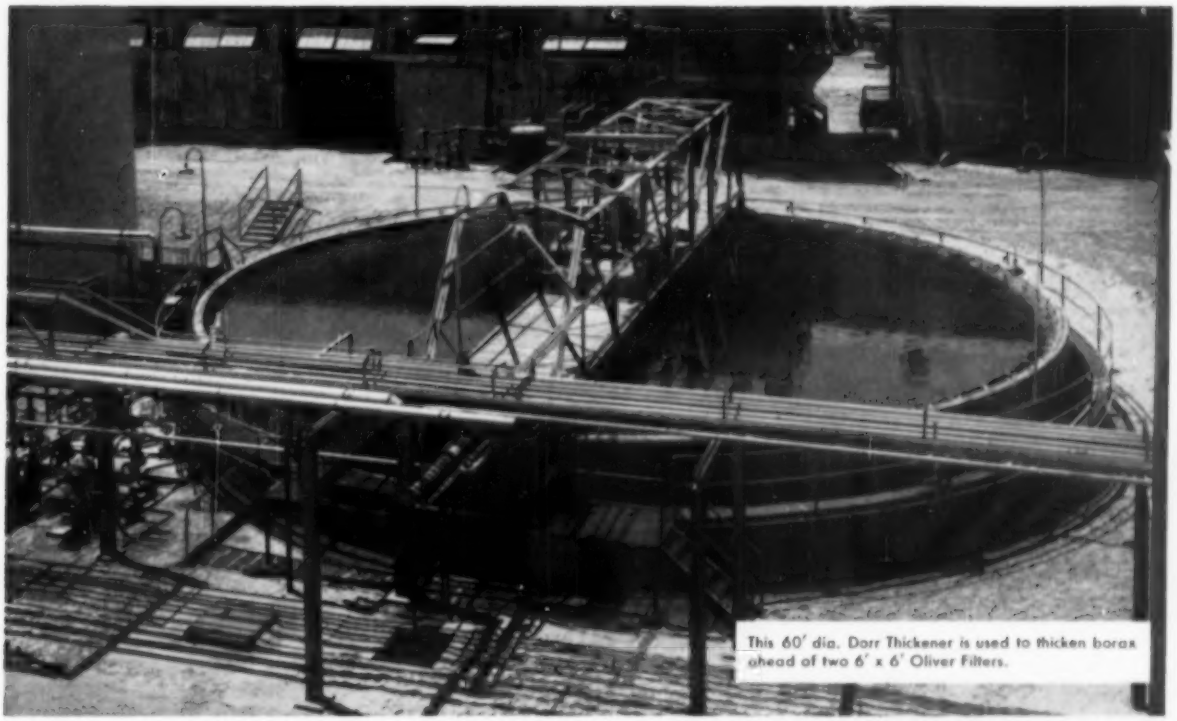
(*Continued on page* 106)

STATEMENT BY FRED A. SEATON, SECRETARY OF THE INTERIOR

"We have high hopes for the Saline Water Conversion Program, provided Congress will appropriate enough money to enable us to carry it out properly. For several conversion processes, we have gone through much of the initial, less expensive research; the time has now come when we must construct pilot plants, and they cost more.

"If current research is successful, in no more than 15 years, and perhaps as few as 5, the cost of conversion of brackish and saline water should descend to the point where they are competitive, for selected purposes in certain areas, with rising costs of fresh water from other sources. Actually, out in California, the Pacific Gas & Electric Company is already using converted water in its fourth-largest steam plant—water which is calculated to cost more than $2.50 per thousand gallons, an amount far higher than industries and municipalities generally pay today.

"In the next decade or so I believe a greater and greater number of industries and municipalities will rely in whole, or part, on converted water."



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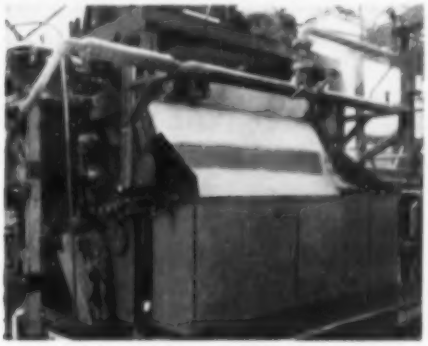

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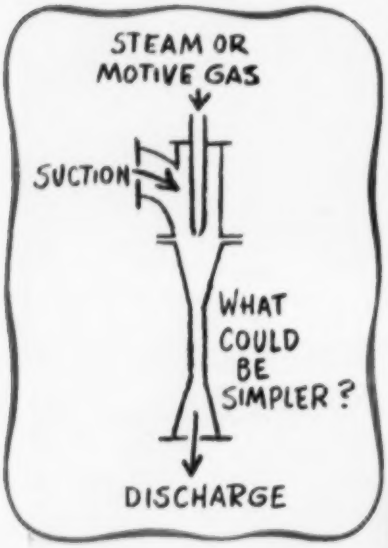

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SALINE WATER

(*Continued from page* 104)

ing economic studies of irrigation projects in the Colorado River Basin and elsewhere indicates that the use of converted sea water for agricultural purposes is unlikely in the forseeable future except perhaps for extremely high value crops near the source of supply.

"The committee concludes, then, that we still have a long way to go before general use of converted sea water becomes a reality and suggests to the Secretary of the Interior that, in these days when water is becoming more and more critical in many parts of the Nation, there is danger in raising false hopes that may contribute to a false sense of Security and deemphasize the immediate need for conserving and making better use of the water we have.

"The committee believes further that the Department is not attaching to this program the degree of urgency it deserves.

"On the bright side of the picture, the committee was impressed by the testimony of Mr. W. L. Badger (Member A.I.Ch.E.), and by the possibilities of the multiple-effect evaporation process he is developing. On the basis of information given the committee on this process, it would appear that authorization for large-scale testing should be obtained immediately, engineering design and other preconstruction activities should be authorized to proceed prior to the completion of the scaling tests and the Department authorized to proceed with negotiations for plant construction with the idea of being ready to start construction immediately when the results of the scaling tests are known.

"Another process that appears to the committee to be impractical for large-scale conversion is the solar still."

Congressman Clair Engle of California had this to say:

"No concrete evidence was presented to the committee as to the measures to accomplish a speed-up in meeting the objective of the program, nor did the Department indicate any immediate need for additional legislation. While it was made clear that pilot plants or demonstration plants of appreciable magnitude to test the more promising processes would require specific congressional authorization, no positive program was presented for getting the demonstration plant phase of the program underway."

While the Office of Saline Water stated during the hearings that certain of the various processes under investigation, such as the Hickman still, a rotary vapor-compression distillation process; the Badger Cycle, a multiple evaporation process; the Ionics, Inc.,

(*Continued on page* 108)

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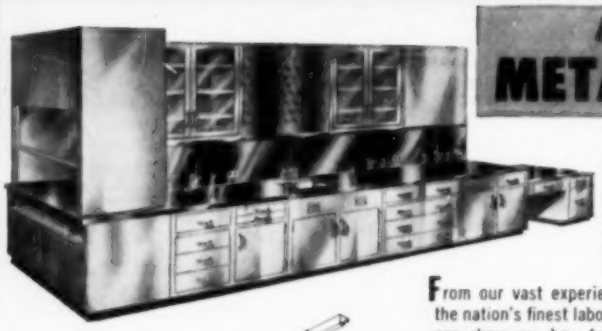

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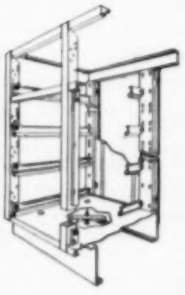

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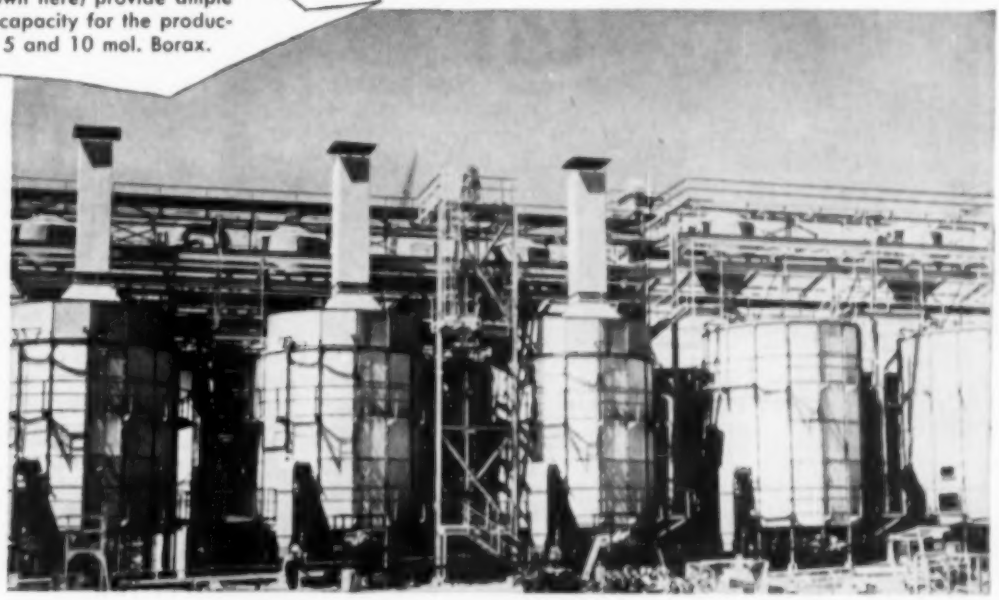

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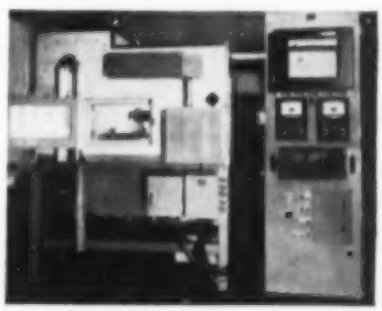

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SALINE WATER

(*Continued from page* 106)

electrodialysis process; the Carrier Corporation freeze-evaporation process; and the Southern Research Institute ismionic process, (the first three of which are now in the pilot plant stage), showed considerable promise, the Committee on Interior and Insular Affairs seems to disagree with the Department of Interior on two major points:

First, the Interior Department sees ultimate promise for some relief from the shortage of water for agriculture through the use of desalted sea water in arid coastal industrial areas, thereby decreasing the present need for bleeding off fresh water from remote agricultural areas. The Committee does not see a good possibility of relief to agriculture based upon currently presented evidence.

Second, the Interior Department believes in pursuing a logical step-by-step research program that is necessarily time-consuming but money-saving. The Committee advocates a more urgent time-saving approach to achieve practicable useful results in a shorter time, even though the cost in money may be greater.

Obviously, the price in dollars one is willing to pay for developing an economical method to desalt sea water depends upon how desperately he needs fresh water.

An International Symposium on Saline Water Conversion is scheduled to be held in Washington on November 4, 5 and 6, 1957, under the sponsorship of the Office of Saline Water, the National Academy of Sciences, and the National Research Council. This should enable us to compare our technological progress in this important field with that of the rest of the world.

The first class of engineers will be graduated in 1961 from Assumption University, Windsor, Ontario, Canada. Plans call for establishment of degrees in chemical, civil, mechanical, and electrical engineering and the construction of a $5,000,000 engineering building. □

Worldwide standards in the plastics field was the goal of a July, 1957, international meeting at Burgenstock, Switzerland, under the auspices of the International Organization for Standardization (ISO). Ninety-five delegates from 16 countries attended the meetings. U. S. delegates, 8 in number, were accredited to the meeeting by the American Standards Association, U. S. member of the 38-country ISO. Action was taken on 16 test methods for plastics with the aim of "laying the foundation for the free flow of raw materials and finished plastic goods into world markets." □

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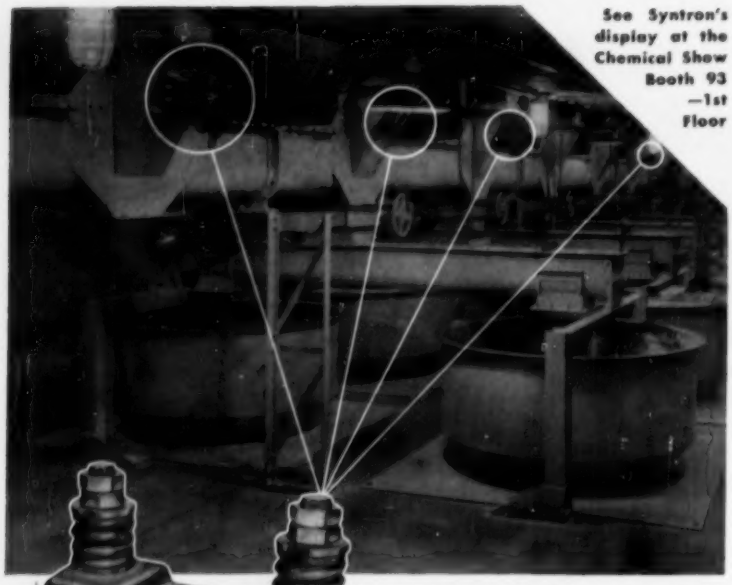
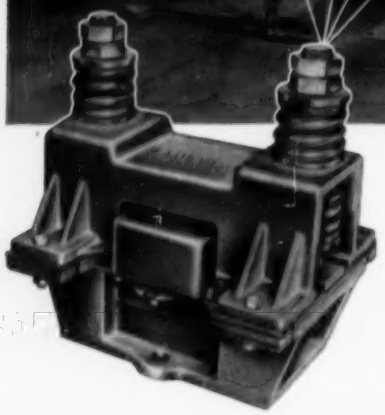


See Syntron's display at the Chemical Show Booth 93 —1st Floor



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FUTURE MEETINGS

(Continued from page 102)

vember 1, 1957. General Chairman: A. K. Oppenheim, Mechanical Engineering, Univ. of Calif., Berkely, Calif.

• **Philadelphia, Pa. June 22-27, 1958. Bellevue-Stratford Hotel. A.I.Ch.E. Fiftieth Anniversary Meeting. CHAIRMAN: Roy** Kinckiner, DuPont, Wilmington, Del. Theme for program is: **A Look to the Future.** All symposia and papers are being planned in accordance with this theme. **Fluid Mechanics, Heat and Mass Transfer**—Organizer: C. R. Wilke. **What Does the Future Hold?**—Organizer: William J. Borns, Socony Vacuum Oil Co., Paulsboro, N. J.

• August 18-21, 1958. A.I.Ch.E.-A.S.M.E. Heat Transfer Conference. CHAIRMAN: A. S. Foust, Dept. of Chem. Eng., Lehigh University, Bethlehem, Pa.

• Salt Lake City, Utah, Sept. 21-24, 1958. A.I.Ch.E. Nat'l. Meeting. CHAIRMAN: E. B. Christiansen, Dept. of Chem Eng., Bldg. 437, Univ. of Utah, Salt Lake City. **Air Pollution**—CHAIRMAN: W. L. Faith, Air Pollution Foundation, 704 S. Spring St., Los Angeles 14, California. **What's New in Liquid Metals Technology**—CHAIRMAN: Marshall Sittig, American Lithium Institute, Inc., P.O. Box 549, Princeton, N. J. **Crystallization**—ORGANIZER: C. S. Grove, Jr., Director of Engineering, Syracuse Univ. Research Institute, Syracuse 10, N. Y. **Foams and Froths**—ORGANIZER: J. Louis York, Dept. of Chemical Engineering, Univ. of Mich., Ann Arbor, Mich. **Ethylene**—ORGANIZER: Hermann C. Schutt, 201 Devonshire Street, Boston, Mass.

• Cincinnati, Ohio, December 7-10, 1958. **Netherland Plaza Hotel. A.I.Ch.E. Annual Meeting. TECHNICAL PROGRAM CHAIRMAN: A. C.** Brown, Emery Industries, Inc., June & Long Streets, Ivorydale, Ohio. **Liquid Pollution**—C. Fred Gurnham, Dept. of Chem. Eng., Michigan State U., East Lansing, Michigan. **Distillation**—CHAIRMAN: W. C. Schreiner, M. W. Kellogg Co., 711 Third Ave., New York 17, N. Y. **High-Speed and Time-Lapse Photography in Chemical Engineering**—CHAIRMAN: J. W. Westwater, William Albert Noyes Laboratory, Univ. of Illinois, Urbana, Ill. **Kinetics & Rate Processes**—CHAIRMAN: H. E. Hoelscher, Dept. of Chem. Eng., John Hopkins Univ., Baltimore 18, Md. **New Approaches for Commercial Chemical Development**—CHAIRMAN: H. E. Wessel, Monsanto Chemical Co., 1700 South Second Street, St. Louis, Mo. **Reprocessing of Fluid Reactor Fuels**—CHAIRMAN: O. E. Dwyer, Chemical Engineering Division, Brookhaven National Laboratory, Upton, L. I., N. Y. **The Application of Computers to Heat and Mass Transfer Problems**—CHAIRMAN: J. M. Smith, Northwestern Univ., Evanston, Ill.

■ **1959 MEETINGS**

• Kansas City, Mo., May 10-13, 1959. TECHNICAL PROGRAM CHAIRMAN: Fred Kurata, Chemical Engineering Dept., Univ. of Kansas, Lawrence, Kansas.

• San Francisco, Calif., December, 1959. TECHNICAL PROGRAM CHAIRMAN: C. R. Wilke, Division of Chemical Engineering, Univ. of California, Berkeley, Calif.

S.O.S.

The Roundtable Discussions held at recent A.I.Ch.E. National Meetings have enjoyed such wide popularity that the Program Committee has decided to emphasize this type of get-together at other meetings in the near future. Suggestions for topics are needed badly and will be welcomed with open arms. Ideas should be sent to E. R. Smoley, Asst. Program Chairman, A.I.Ch.E., Lummus Co., 385 Madison Ave., New York 17, N. Y.

Courtesy N. Y. Central

biggest technical program

H. F. Nolting and A. L. Conn, | Standard Oil (Indiana)

The Chicago Annual Meeting, December 8-11, will offer the biggest technical program ever presented by A.I.Ch.E., will have four simultaneous sessions for the entire length of the meeting—not to mention the Institute Lecture, the Awards Banquet, Committee meetings, presentation of new officers, and the unique new Discussion Session. The Plant Trip list is long and varied, and all in all the chemical engineers will have something of major importance to themselves and their companies just about every minute of the four days.

Recent addition to the Technical Program is the Discussion Session. These are informal "talkfests" which will take any technical direction the participants want. Limited to 50 attendees, surroundings will be geared for comfort, subjects will be "hot off the griddle." One session will run concurrently with each technical program session.

SUNDAY, DECEMBER 8

PANEL DISCUSSION—PROVIDING A GOOD WORKING CLIMATE FOR THE ENGINEER IN INDUSTRY, R. R. Paxton, General Electric, moderator.

A panel has been assembled to hear and review your ideas on how to improve the many elements comprising a working environment.

Panelists: A. Patton, McKinsey & Co.; M. T. Carpenter, Standard Oil; C. W. Muhlenbruck, Engineer & Technical Consultants; D. A. Dahlstrom, The EIMCO Corp.

MONDAY, DECEMBER 9

SPECIAL SESSION, J. H. Rushton, Purdue, presiding.

Ninth Annual Institute Lecture.

Annual Business Meeting.

1—CHEMICAL ENGINEERING ABROAD, S.A. Miller, U. of Rochester, presiding. (Simultaneous with sessions 2, 3, and 4).

In the past the excellent basic research of Russia and the Western European countries was not commercialized because of the lack of tools to bridge the gap. However, there has been a sharp growth in industrial development in these countries, inspired and furthered in part by chemical engineering.

Chemical Engineering In Great Britain, J. E. Myers, Purdue.

British chemical technology is older than the concept of chemical engineering, but chemical engineering as a separate discipline is just coming into its own.

Chemical Engineering in France, A. Rose, Olin Mathieson.

Industrial chemistry rather than chemical engineering has been the tradition in France, but new concepts have begun to catch on since the war.

Chemical Engineering in Germany, R. Landau, Scientific Design Co.

In Germany the chemical enginer is composed of two men: an industrial chemist and a "verfahrens Ingenieur." This paper will analyze why, how, and what American chemical engineers can learn from the German system.

Traditional Aspects of Chemical Engineering Education in Italy, J. O. Maloney, U. of Kansas.

Ancient traditions and modern subject matter clash headlong in Italian chemical engineering education.

Contract Chemical Research in Europe, F. C. Croxton, Battelle; and M. A. W. Barnick, Battelle in Frankfort/Main, Germany.

A recent innovation, contract research institutes have proven a success in Europe.

2—SHOCK WAVES IN PROCESS EQUIPMENT, S. Churchill, U. of Mich., presiding. (Simultaneous with sessions 1, 3 & 4.)

While the process industries have established a good safety record, the occasional fires and explosions emphasize the need for constant vigilance. With losses sometimes running into the tens of millions of dollars, a knowledge of shock waves is vital to the chemical engineer.

The Destruction of a Large Refinery Unit by Gaseous Detonation, R. B. Jacobs, W. L. Bulkley, J. C. Rhodes, and T. L. Speer, Standard Oil (Indiana).

A step-by-step account of the almost complete destruction of a large Fluid Hydroformer by a series of internal detonations.

Impact Pressures Developed in Hydrogen-Oxygen Detonations, M. P. Moyle, DuPont; and S. W. Churchill, U. of Mich.

Detonation velocities calculated for gaseous mixtures containing from 20 to 80 per cent hydrogen in oxygen over a temp. range from —100° to 480° F., and a pressure range from 7.35 lbs./sq. in. abs. to 29.40 lbs./sq. in. abs.

Fracturing Under Explosive Loading, J. S. Rinehart, Smithsonian Inst.

Problems peculiar to the fracturing of metal bodies under impulsive loads.

Plate Velocities In Impulse Loading by Detonation Waves, R. B. Clay, M. A. Cook, R. T. Keyes, U. of Utah.

An experimental study of the velocities of metal plates at the ends of point initiated.

The Effects of Gaseous Detonation Upon Vessels and Piping, P. N. Randall, J. Bland, W. M. Dudley, and R. B. Jacobs, Standard Oil (Indiana).

Three effects from the application of shock pressure from a gaseous detonation, with case histories of major explosions.

3—COST CONTROL IN PROCESS OPERATIONS, F. R. Fisher, Sinclair Refinery Co., presiding. (Simultaneous with sessions 1, 2 and 4.)

Markets are now becoming more competitive and industry is facing a situation where unit cost of product must be minimized to retain profit levels. This symposium covers a wide field of cost control methods in a cross section of the processing operations in which chemical engineers play a major part.

Methods of Using Super-Computers to Plan Processing Operations, Tankage Utilization, and Equipment Scheduling, J. W. Davie, Esso Standard Oil Co.

High speed electronic computers—or punched card equipment—can effectively produce the conventional type of process cost control reports, but with the basic data in a large-scale computer much more can be done.

Cost Trends and Cost Control in the Processing of Pharmaceuticals, C. R. Bartels, Squibb Inst. for Medical Rsch.

Cost trends as affected by wholesale drug prices are examined briefly and it is found that price changes of certain drugs are predictable.

A Cost Reduction Program That Works, R. Gutoff, General Electric.

An extremely successful cost reduction program has been in operation in GE's Silicone Dept. for six years, has resulted in savings amounting to about eight per cent of annual manufacturing costs, is applicable to many complex chemical operations.

Cost Controls in the Processing of Uranium, H. E. Thayer, Mallinckrodt.

Mallinckrodt has developed a system for estimating, measuring, reporting, and controlling costs which has been used for years, has proven highly successful.

4—GENERAL PAPERS, PART I, J. E. Anderson, Standard Oil (Indiana), presiding. (Simultaneous with sessions 1, 2 and 3.)

Local Boiling Coefficients on a Horizontal Tube, R. P. Lance, J. R. Myers, Purdue.

Experimental determination of local boiling heat transfer coefficients around the outer circumference of horizontal copper tubing.

Local Shell-Side Heat Transfer Coefficients in Baffled Tubular Heat Exchangers, T. W. Ambrose, J. G. Knudsen, Ore. State Coll.

An experimental study of local heat transfer coefficients in a baffled tubular heat exchanger for five baffle spacings and two tube spacings.

Individual Film Coefficients of Mass Transfer in Liquid-Liquid Extraction, G. C. Smith, DuPont, and R. B. Beckman, Carnegie Tech.

A study of the individual film coefficients of mass transfer for two binary liquid-liquid systems of differing physical properties.

Radial Porosity Variations in Packed Beds, L. H. S. Roblee, Purdue; R. M. Baird, DuPont; and J. W. Tierney, Remington Rand Univac.

An experimental examination of the radial variation of void fraction in randomly packed beds of spheres, cylinders, raschig rings and berl saddles.

Axial Dispersion of Mass In Flow Through Fixed Beds, J. J. Carberry and R. H. Bretton, Yale U.

The axial dispersion of water flowing through fixed beds was determined by measuring and recording the dispersion of pulse input of dye at one or two points downstream of the injection site.

5—8:30 P.M. SPECIAL SESSION—CHEMICAL ENGINEERING ABROAD, PART II—THE U.S.S.R., S. A. Miller, U. of Rochester, presiding.

Chemical Engineering n the U.S.S.R., J. G. Tolpin, Standard Oil.

Specialization was the order of the day in the Soviet, but now that the country has caught-up industrially the trend is toward basic enginering science much as in the U.S.

Report on a Visit to Some Soviet Chemical Engineering Education Centers and Industries, E. L. Piret, U. of Minn.

First hand report on the trip just completed by Prof. Piret.

TUESDAY, DECEMBER 10

6—EXTRACTIVE METALLURGY, PART I, B. W. Gamson, Borg-Warner, presiding. (Simultaneous with sessions 7, 8, and 9.)

The nuclear era has focused attention on a series of metallurgical processes related to a group of exotic elements that were virtually unknown on the industrial scene prior to 1940, leading to the exploitation and development of new extractive metallurgical techniques for two chief classes of elements: those related to fissionable fuels; and those related to the moderating and structural materials for reactors.

Hydrometallurgy—A Survey of Principles and Processes, F. A. Forward, U. of British Columbia.

The principle features of hydrometallurgical processes are outlined, technology is described with particular attention to more recent developments.

Design of a Plant for Recovery of Uranium by Liquid Ion Exchange (Solvent Extraction), Kathleen Black and J. Koslov, Vitro.

Design, process description, operating and design variables, and a brief cost summary of Vitro's new mill for the recovery of uranium from sulfuric acid leach solutions by solvent extraction.

Slurry Extraction of Uranium in a Pilot Plant Pulse Column System, D. S. Arnold, B. G. Ryle, J. O. Davis, National Lead of Ohio.

A liquid-liquid extraction system for the recovery and purification of uranium from acid slurries of various ores and ore concentrates.

Application of Gamma Radiation Density to Gauging Extraction Column Measurement and Control, H. F. Mulhauser and B. G. Ryle, National Lead of Ohio.

The feasibility of gamma absorption density gauging for measurement of uranium concentration in liquid-liquid extraction is demonstrated on a pulsed perforated plate column.

Engineering Continuous Filtration to the Uranium Ore Processing Flow Sheet, D. A. Dahlstrom, C. F. Cornell, and R. C. Emmett, The EIMCO Corp.

Presentation and detailed analysis of all filter station flow sheets in uranium processing.

7—LABORATORY AND PILOT PLANT TECHNIQUES, PART I, G. W. Blum, Goodyear, presiding. (Simultaneous with sessions 6, 8 and 9.)

Chemical engineers who are concerned with the direction or operation of pilot plants are aware of the importance of careful planning to provide maximum flexibility in design and in the recognition of poor projects. Unlike past symposia concerned with design and operating details, this session will concentrate on the economic planning of pilot plant programs.

Planning of Pilot Plant Experiments, J. E. Pierce, Dow.

A systematic method of planning pilot plant operations, reviewing progress, reappraising goals and objectives, and budgeting costs.

Selecting the Kind and Size of Pilot Plants, K. C. Peterson, N. Fragen, and G. H. Weisemann, Standard Oil (Ind.).

The types of information required, the characteristics of the processes under study, and the quantities of samples required, all influence kind and size of pilot plant.

Toxic Area Semi-Works, A. S. West, Rohm & Haas.

Of growing importance is the proper design to provide for safe handling of toxic materials in semi-works plant.

Left is the Conrad Hilton hotel, meeting headquarters, and the skyline of Chicago overlooking Grant Park on the shore of Lake Michigan. Large underground parking garage is beneath the beautiful park.

8—THE EVALUATION OF PROJECTS FROM THE ORIGINAL IDEA TO THE COMMERCIAL PLANT, R. Dressler, consultant, presiding. (Simultaneous with sessions 6, 7 and 9.)

Today, top management realizes that continuous evaluation of projects is essential for earliest realization of profits, maximum return on investment, and timely discontinuance of unprofitable projects.

The Basic Data Consultant in Process Evaluation, E. L. Mongan and W. S. Gilfoil, DuPont.

The functions and qualifications of the consultant. Discussion of the amount and type of information required for economic design of commercial facilities.

Pilot Plant Development of Marlex 50 Polyethylene, E. W. Mellow, M. R. Cines, G. H. Dale, and R. E. Weis, Phillips Petroleum.

Emphasis is placed on the timing and the factors influencing each major step in steering the accelerated project toward large scale commercialization.

Optimum Design Capacity, T. W. Timpe, Colgate-Palmolive.

Case History of the Development of Diamond's Process for the Manufacture of Perchloroethylene, J. J. Lukes, Diamond.

How Diamond organizes its research work, pilot plant work, product quality investigations, etc.

Evaluation of Research Projects, R. J. Hengstebeck and W. W. Sanders, Standard Oil (Ind.).

How evaluation works, when and how to use the results, when to make the evaluation to get the most out of it.

9—GENERAL PAPERS, PART II, G. Thodos, Northwestern U., presiding. (Simultaneous with sessions 5, 7 and 8.)

Critical Temperatures and Pressures of Hydrocarbons, J. C. Forman, Abbott Labs.; and G. Thodos, Northwestern.

A method will be presented which permits the calculation of both van der Waals' constants for common hydrocarbons. With these constants critical temperatures and pressures can be calculated directly.

Viscosity of Liquid Mixtures of Normal Paraffins, L. F. Albright, Purdue; and T. D. Perkins, U. of Okla.

Experimental viscosity measurements are used to test several methods of predicting the viscosities of mixtures.

Identification of Rheological Properties of Vinyl Resin Plastisols, H. L. Gunnerson, and G. W. Blum, Goodyear; and M. B. Palmer, Kent State U.

The non-Newtonian index and consistency are discussed and analyzed as concerns their measurement, and it is shown that they are useful in the identification of the rheological properties of the plastisols.

Mechanics of Turbulence in Non-Newtonian Systems, A. B. Metzner, and D. W. Dodge, U. of Delaware.

The first theoretical attack in the area of turbulent non-Newtonian flow yields a completely new concept of the attending pressure loss-mean flow rate relationship.

10—EXTRACTIVE METALLURGY, PART II, F. A. Forward, U. of British Columbia, presiding. (Simultaneous with sessions 11, 12 and 13.)

Part 2 of this session is based on some of the more exotic minerals and their production techniques. The future of the nuclear industry is, in many respects, predicated upon the developments outlined in this symposium.

Extractive Metallurgy of Beryllium, K. B. Higbie and M. C. Farmer, Beryllium Corp.

Process employed for the extraction of beryllium oxide from beryl.

Liquid-Liquid Extraction of Zirconium and Hafnium, I. S. Zoris and W. H. Keller, Columbia National Corp.

After a review of the several possible systems for separating zirconium and hafnium, the reasons for selecting the "Nitrophos" liquid-liquid extraction process, using a nitric acid-tributyl phosphate system, are discussed in full detail and commercial plant design is described.

PLANT TOURS

Trip No.	Place
M-1	Argonne National Laboratory
M-2	International Harvester Corp. West Pullman Works
M-3	Abbott Laboratories
M-4	Armour Research Foundation
M-5	Chicago Board of Trade
M-6	Standard Oil Company of Indiana Whiting Refinery
M-7	United States Steel Corporation
M-8	International Harvester Corp.
M-9	Salerno-Megowen Biscuit Company
M-10	Chicago Tribune, Inc.
T-11	United States Steel Corporation Gary Works
T-12	Standard Oil Company of Indiana Whiting Refinery
T-13	Sinclair Research Laboratories, Inc.
T-14	Metropolitan Sanitary District
T-15	Chicago Tribune, Inc.
T-16	Armour Research Foundation
T-17	Mars, Incorporated
T-18	Argonne National Laboratory
T-19	United States Steel Corporation Gary Works
T-21	Northwestern Technological Institute
W-22	Corn Products Refining Company
W-23	Sherwin-Williams
W-24	Chicago Board of Trade
W-25	Standard Oil Company of Indiana Whiting Refinery
W-26	Abbott Laboratories

Simultaneous Distillation of Ammonia and Separation of Copper from Nickel Bearing Solutions, V. N. Mackiw, R. L. Benoit, R. J. Lorce, and N. Yoshida, U. of Brit. Columbia.

Detailed description and analysis of a relatively new process now in successful commercial operation in Canada.

Separation of Niobium and Tantalum by Liquid Extraction, E. L. Koerner, Jr., M. Smutz, and H. A. Wilhelm, Electromet.

The preparation of high-purity niobium and tantalum oxides from a columbite ore by a simple inexpensive process.

Tantalum and Columbium—Their Extractive Metallurgy, D. F. Taylor, Fansteel Metallurgical Corp.

Invariably found in the same ore, and separated with difficulty, the extractive metallurgy of these metals is difficult.

Lithium Extraction from Run-of-Mine Spondumene Ore, H. J. Andrews, Lithium Corp.

Engineering details, and problems, of the sulfuric acid process for the extraction of lithium from run-of-mine spondumene ore.

MEETING PROGRAM

11—LABORATORY AND PILOT PLANT TECHNIQUES, PART II, J. T. Cumming, Fenn College, presiding. (Simultaneous with sessions 10, 12 and 13.)

Small Scale Pilot Plants for High Pressure Research, P. A. Lobo, Continental Oil; and C. M. Sliepcevich, U. of Okla.

The features of design encountered in small scale pilot plants for research in the pressure ranges of 3,000 to 25,000 lbs./sq. in. for contacting towers of gas liquid reactions, fixed bed catalytic units, and tubular reactors for the study of homogeneous reactors.

Rapid, Sensitive Temperature Measurement with Thermistors, L. A. Wenzel and R. J. Adler, Lehigh Univ.

A thermistor method of measuring and controlling rapidly fluctuating temperature in a response time of considerably less than one second.

Development of an Interconnected Pilot Plant and Laboratory System at Dow Corning, W. R. Collings, D. E. Hook, H. J. Fletcher, and W. Poulus, Dow Corning.

A detailed case history of a complex development program on silicones.

Fundamentals of Spray Drying Detergents, J. H. Chaloud, Procter & Gamble.

New developments which establish and confirm fundamental principles encountered in the spray drying of detergents.

Engineering Aspects of a Houdriflow Pilot Plant, R. E. Ledley, Jr., and W. B. Patterson, Jr., Sun Oil Co.

Details of the engineering aspects of a Houdriflow pilot plant for the studying of process variables.

12—SELLING A TECHNICAL PROGRAM, D. Murphy, Service Pipe Line Co., presiding. (Simultaneous with sessions 10, 11 and 13.)

Communications are a necessity not a novelty—over 80 per cent of the time spent by management in a company is spent on communications. This session will try to find out **why** management approves certain programs, disapproves others.

Hitting the Bullseye, H. L. Rusch, Opinion Research Corp.

The problem of knowing what the other fellow is thinking, of finding out what his position is so that you can "hit the bullseye" with your proposed program.

Send Up A Graphic Report, E. B. Savage, Savage-Lewis, Inc.

All else being equal, the written report to management is the best method of communication.

Spreading the Data, H. D. Wilde, Humble.

After completion of the project, the data must be used. It is part of the engineer's job to help spread the results.

Data Don't Talk, P. C. White, Standard Oil (Indiana).

Research results require just as much selling as any new product.

Selling to the Public, C. L. Black, Hill & Knowlton.

The consumer is the ultimate goal of the technical program; if the public is not sold, the project has failed.

13—THE SEPARATION OF MATERIALS IN BIOLOGICAL PROCESSES, E. L. Gaden, Columbia Univ., presiding. (Simultaneous with sessions 10, 11 and 12.)

Major engineering problems are involved in

the separation of biologically produced materials. This session will present the very latest techniques for separating and recovering such materials, covering the special operations very little known outside the companies which use them.

Relative Transfer of Ions in Permselective Membrane Systems, A. T. DiBenedetto, and E. N. Lightfoot, U. of Wisc.

Equations are developed for predicting the relative transport of ions across permselective membranes.

Engineering Problems in Large-Scale Continuous Electrophoresis, R. K. Finn, and R. Dobry, Cornell Univ.

Electrophoresis involves migration of charged particles in electrical fields. The basis of separation is that each component of a mixture moves at a characteristic speed. This is a full-scale study of the attempt to utilize the method on a large scale.

Foam Separation in Protein Solutions, R. W. Schnepf and E. L. Gaden, Jr., Columbia Univ.

Determination of the effects of pH and concentration on the separations obtained by foaming aqueous solutions of the protein, bovine serum albumin.

A Novel Ion Exchange Method for Isulation of Streptomycin, G. Kleiman, C. R. Bartels, D. Irish, and J. Korzun, Squibb Inst. for Medical Research.

The development and final design of an ion-exchange process which can handle whole fermentation broth and thereby eliminate the filtration step with its problems.

The Drying of Viable Biological Materials by Solvent Extraction and Azeotropic Distillation, R. R. Freeman and T. R. Dashiell, Chemical Corps; M. A. Auro, Dow; I. Oshrine, Wyeth; J. E. Murphy and R. F. Smith, DuPont.

Two chemical processes, azeotropic distillation and solvent extraction, have been applied to the dehydration of viable biological materials. Modifications to make the processes continuous seem feasible.

WEDNESDAY, DECEMBER 11

14—NUCLEAR PROCESS HEAT, B. W. Gamson, Borg-Warner, presiding. (Simultaneous with sessions 15, 16 and 17.)

In order to stimulate more thinking along the lines of direct application of nuclear reactors to metallurgical processes, chemical systems, and the direct production of process heat, this symposium has been developed to give insight into some of the problems related to this new and challenging application of nuclear energy.

Process Steam Reactor, E. L. Heller, and D. O. Hubbard, H. K. Ferguson Co.

A process steam reactor is described that can produce steam at a cost equal to or less than the cost of steam from fossil fuels.

High Operating Temperature Reactor Design, J. DeFelice and L. Davidson, Nuclear Dev. Corp.

Preliminary design of a nuclear reactor which will produce 2500° F. helium. Design of this reactor is the first step in the development of a nuclear reactor for chemical processing.

High Operating Temperature Reactor—Materials and Process, L. Davidson and J. DeFelice, Nuclear Dev. Corp.

Means of producing high temperatures for existing chemical processes are reviewed, and the features of processes which might be amenable to nuclear heat are indicated.

Nuclear Considerations in Design of High Temperature Process Heat Reactors, J. T. Roberts, ORNL.

Differences in performance characteristics of 2000-3000°F. nuclear reactors as compared to low temperature "thermal reactors."

Indirect Cycle Nuclear Reactor System to Furnish Process Heat, J. P. McGee and R. G. Dalzell, Bureau of Mines.

Major problems are cited as high temperature fuel element design, an exchanger to transfer heat to process streams in the range of 2,500° F., and development of compressors to recycle helium at temperatures of 1,000° F. and above.

15—FLUIDIZATION OF SOLIDS, PART I, E. R. Gilliland, MIT, presiding. (Simultaneous with sessions 14, 16 and 17.)

In two parts, the first group of papers in this session will concern the utility of beds of fluidized solids for heterogeneous catalysis of chemical reactions. Particular emphasis is placed on the contact between the solid and fluid which involves the mass transfer and flow characteristics.

Density Fluctuations in Fluidized Beds, P. K. Baumgarten, DuPont; and R. L. Pigford, U. of Delaware.

The effectiveness of fluidized beds is limited by the presence of density fluctuations such as those caused by gas bubbles. The size and frequency of such bubbles were measured.

Factors Affecting Density Transients in a Fluidized Bed, J. M. Dotson, General Electric.

The effects of five operating variables on the uniformity of fluidization in a four inch diameter column determined by a statistically designed experiment.

Surface Dynamics of Fluidized Beds and Quality of Fluidization, W. J. Rice and R. H. Wilhelm, Princeton Univ.

Solutions of the linearized Navier-Stokes equation have been developed for the motion of arbitrary two-dimensional waves occurring at any interface between the "emulsion" phase of a fluidized bed and the particle-free fluid phase.

Movie—Fluidization Characteristics in a Two-Dimensional Fluid Bed, D. B. Todd, R. H. Overcashier, and R.. B. Olney, Shell Development Co.

Movies of thin two-dimensional beds provide visual observation of many factors of importance in large three-dimensional beds.

Kinetic Study of Fluidized Solids Entrainment, J. M. Andrews, Humble Oil.

By considering the system kinetics, the entrainment in a fluidized solids system has been related to the physical properties of the system and a statistical function of the bed outage in a special equation.

Pressure Drop and Power Requirements in a Stirred Bed, M. Leva, consulting engineer.

Pressure drop characteristcs and power requirements of stirred fluidized beds determined for various types of stirrers and modes of stirring.

Generalized Correlations for Free Fall and Multi-Particle Systems, C. E. Jahnig, Esso Research & Eng.

A simple relationship is shown between free fall velocity, minimum fluidizing velocity, and the corresponding maximum local velocity in a bed.

16—CORROSION RESISTANT ALLOY MATERIALS OF CONSTRUCTION, G. F. Ours, Union Carbide Chemicals, presiding. (Simultaneous with sessions 14, 15 and 17.)

Chemical engineers have a vital interest in corrosion problems, and in alloys developed to resist corrosion.

Corrosion and Its Manifestations, M. G. Fontana, Ohio State U.

The general principles of corrosion by electrolytes and attack at high temperatures or high temperature oxidation in simplified form. Designed for the engineer not a corrosion expert.

Stainless Steel for Corrosion Resistance, L. R. Honnaker, Du Pont.

The stainless steels, their excellent corrosion resistance, and particularly the causes and means of avoiding the unexpected failures from special types of corrosion such as pitting, stress corrosion, etc.

Copper Alloys for Corrosion Resistance, R. V. Hall, Bridgeport Brass Co.

Detailed discussion, with examples, of the use of copper alloys and the problems involved.

Methods of Solving a Corrosion Problem, J. Halbig, Armco Steel.

The logical steps to follow in investigating a failure due to corrosion.

17—GENERAL PAPERS, PART III, J. F. Tourtellotte, Swenson Evaporator, presiding. (Simultaneous with sesssions 14, 15, and 16.)

The Effect of Water Vapor on the Catalytic Oxidation of Nitric Oxide, O. Kircher, Continental Oil; O. A. Hougen, Univ. of Wisc.

Experimental work using activated carbon and silica gel as catalysts, done in an isothermal series integral flow reactor.

Particle Size Control in Fluid Coking, D. D. Dunlop, L. I. Griffin, Jr., and J. F. Moser, Jr., Esso Standard Oil Co.

The theory and laboratory work involved in the solution of the particle size problem in fluid coking.

Water Reservoir Evaporation Control for Industry, R. G. Dressler, consultant; and A. G. Johanson, Archer-Daniels-Midland.

A presentation, for the first time to chemical engineers, of the newly developed monomolecular film techniques for retarding evaporation from reservoirs.

Standardization of Centrifugal Chemical Pumps, C. J. B. Mitchell, DuPont.

Detailed case history of producer and consumer needs and of standards now being formulated.

Eastman Process for Manufacture of Acetylene and Ethylene, G. A. Akin, T. F. Reid, and R. J. Schroeder, Tenn. Eastman.

Detailed discussion of the nature of the process for producing acetylene from light hydrocarbons, including equipment, practices, yields, etc.

The Characteristcs of a Mechanically Agitated Gas-Liquid Contacting System, R. A. Bernard, Du Pont.

Experimental work leading to some conclusions regarding the mechanism of the contacting process.

18—RADIATION PROCESSING, J. J. Martin, Univ. of Mich., presiding. (Simultaneous with sessions 19, 20 and 21.)

The impact of radiation processing on the chemical industry will probably not be felt for some time due to the few available sources, but at this stege fundamental research is being conducted on the ways of using radiation in the promotion of chemical reactions.

Effect of Gamma Radiation on Hydrogenation of High Molecular Weight Alkanes and Aromatics, E. J. Henley, L. Karasyk, and R. V. Repetti, Columbia U.

An investigation to determine the effects of gamma radiation on hydrogenation reac-

MEETING PROGRAM

tons, marked changes were noted in high molecular weight alkanes and aromatics.

Experimental Determination of Dose Distribution in the Proposed Fir Gamma Irradiator, B. Manowitz, D. M. Richman, O. A. Kuhl, and L. Galanter, Brookhaven.

Experimental determination of the dose distribution in the proposed Food Irradiation Reactor.

Direct Utilization of Fission Energy for Radiation Processing, W. Diethorn, P. Schall, and G. D. Calkins, Battelle.

The direct utilization of fission recoil energy for ionizing various chemicals and causing them to react.

Radiation Source Fabrication and Handling, E. Lamb, ORNL.

Radiation source fabrication and handling at the new Oak Ridge plant which will make concentrated gamma radiation sources from waste fission products.

Design and Construction Criteria for In-Pile Experimental Chemical Reactors, D. D. Foley, D. J. Daniels, M. C. Schroeder, and R. B. Filbert, Jr., Battelle.

The design and construction problems which must be handled when building chemical reactors which are to be placed inside nuclear piles.

The Effects of Gamma Radiation on Several Polysulfone Reactions, B. G. Bray, L. C. Anderson, and J. J. Martin, U. of Mich.

The effects of gamma radiation from cobalt-60 on the copolymerization reactions of sulfur dioxide with various hydrocarbons.

19—FLUIDIZATION OF SOLIDS, PART II, E. R. Gilliland, presiding. (Simultaneous with sessions 18, 20, and 21.)

Data on the mechanism of the fluidization of solids, and basic principles.

The Effect of Liquid on Interparticle Forces in Gas Fluidized Beds, H. W. Parker and W. F. Stevens, Northwestern.

A theory is developed to explain the effect of interparticle forces on bed height for a gas-fluidized bed.

Slow Motion of Fluid Flow Relative to Beds of Spherical Particles, J. Happel, NYU.

A mathematical model is developed for predicting the effect of voidage on resistance to fluid flow through a bed of spherical particles.

Some Effects of Baffles on a Fluidized System, R. H. Overcashier, D. B. Todd, and R. B. Olney, Shell Development.

Comparison of the changes in solids and gas flow characteristics brought about by various baffles.

Study of Gas-Solid Contacting with Ozone Decomposition Reaction, C. G. Frye, W. C. Lake, and H. C. Eckstrom, Pan American Petroleum.

For those reactions in which the study of gas-solid contacting is difficult, a simple substitute reaction for study is the catalytic decomposition of ozone in a dilute mixture with air.

Solid Catalyzed Reaction in a Fluidized Bed, W. Glass, Esso Research & Eng.; and W. K. Lewis and E. R. Gilliland, MIT.

Results are presented for the solid catalyzed hydrogenation of ethylene in fixed and fluidized beds.

Gas-Solids Contacting in Fluidized Beds Measured by Tracer Experiments, W. G. May, Esso Research & Eng.

(Continued on page 116)

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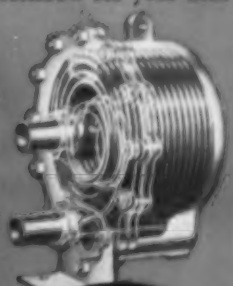

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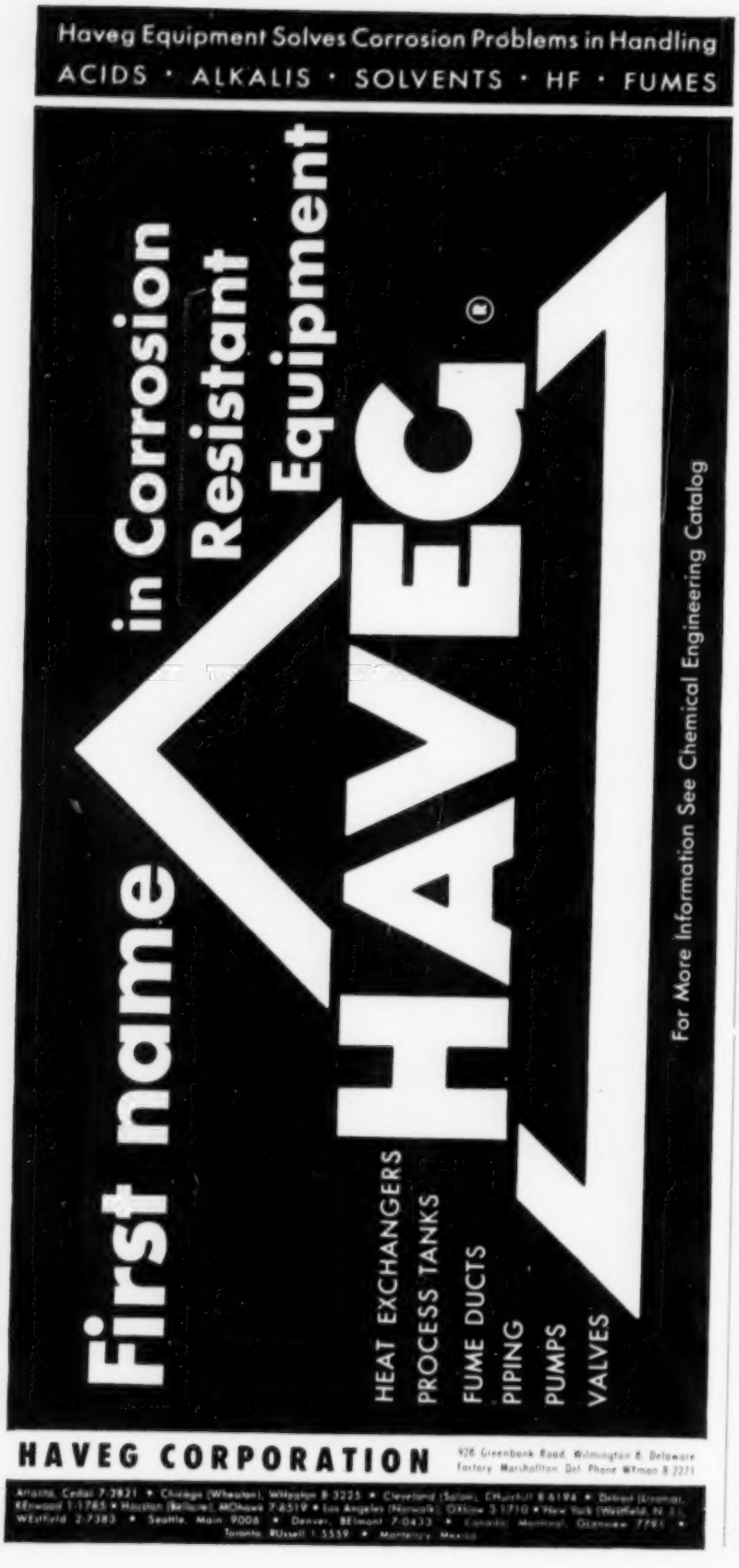

MEETING PROGRAM

(Continued from page 115)

Tracer experiments used to measure the effects of gas back-mixing and mass transfer between bubbles and the gas-solids mixture.

20—APPLICATION OF COMPUTERS IN OPTIMUM DESIGN AND OPERATION OF PROCESS EQUIPMENT, L. Cooper, Monsanto, and Chen-Jung Huang, U. of Houston, presiding. (Simultaneous with sessions 18, 19, and 21.)

Thermal Stress Analysis of Refinery Piping Systems, G. N. Smith, Fluor.

How, through the use of a digital computer, the designer obtains a more complete knowledge of the behavior of the piping system.

Optimum Design of Perforated Tray by Computer, Chen-Jung Huang, U. of Houston.

The logical and systematic use of a computer to select an optimum tray layout.

Engineering Application of Relaxation Procedures by Digital Computation, M. E. Radd, and M. R. Tek, Phillips Petroleum.

A generalized computing method is developed to perform mathematical "Relaxation" on a Datatron digital computer.

Development of a Refinery Simulation Program, J. S. Bonner, and J. F. Moore, Bonner & Moore Eng. Assoc.; and W. L. Pyles, Eastern States Petroleum.

The simulation of a complete refinery of nominal 65,000 bbl. capacity with a medium size digital computer.

Application of a General Purpose Analog Computer in the Design of a Cooler-Condenser, R. G. E. Franke, and N. G. O'Brien, Du Pont.

How the conditions in the condenser are established continuously and automatically for every point, and how the required heat transfer area is found at the same time.

21—CHEMICAL RECOVERY IN THE PULP AND PAPER INDUSTRY, R. P. Whitney, Inst. of Paper Chemistry, presiding. (Simultaneous with sessions 18, 19, and 20.)

Chemical Engineering Applications in Handling Spent pulping Liquors, R. P. Whitney.

The present situation in the handling of spent pulping liquors, with particular reference to the chemical engineering applications involved.

Heat Transfer Coefficients of Ammonia Base Sulfite Waste Liquor in a Long Tube, L. C. Jenness, U. of Maine.

Experimental data gathered with a pilot plant evaporator with stainless steel vertical tubes and vapor head.

Heat Transfer Studies in the Evaporation of Neutral Sulfite Spent Liquors, S. T. Han, and B. D. Andrews, Inst. of Paper Chemistry; and W. G. Dedert, Swenson Evaporator Co.

The results of an investigation of the evaporation of neutral sulfite spent pulping liquor in a semi-commercial, forced circulation, evaporator.

Chemical By-Products from Spent Sulfite Liquors, L. M. Whitmore, Jr., and A. J. Wiley Sulfite Pulp Mfg.'s Resch. League.

A number of processes have been developed and are now being used to obtain commercially useful products from sulfite waste liquor.

Chemicals From Tall Oil by Liquid Extraction, E. G. Scheibel, York Process Equip.

Separation of tall oil components by fractional liquid extraction.

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MAJOR CHEMICAL INDUSTRY—NAVAL STORES

C. E. Tyler, Hercules Powder Co., outlines the steadily growing operations of the ancient naval stores industry to the May meeting of the Savannah River Section (R. O. Pekkala).

Rosins for the naval stores industry are secured from two major sources—pine trees and pulpwood. The pine tree rosin in turn comes from the live trees and from the aged stumps. (Since the resins produced by pine trees are deposited in the dead core of the tree, and since these cores are resistant to rot and insects, the ancient stumps are a rich source.)

Overall industry production has shown a slow but steady climb. While gum rosin production has fallen off, rosin from stumps and pulpwood has offset this deficit. Competition is keen between the three major processes and the high cost of harvesting has caused the gum rosin process to lose ground. Apparently the wage scale for the harvesting crew has to be so low that labor is not available. Labor cost is greatly reduced in the harvesting of stumps and pulpwood because of considerable mechanization.

Latest figures given by Tyler showed that in the year 1953-54, 657 million pounds of rosins were consumed in this country. Biggest customer was the paper industry for the sizing of paper.

Other Resins

The general structural formula for the resins other than rosins produced by the naval stores industry is a phenanthrene, 3-ring molecule, somewhat similar to the structural formula for anthracene. But the subject is complex, there are many resin formulae and bondings.

The chemical reactions of naval stores resins are highly susceptible to any thermal driving force. These resins are generally easily oxidized. In producing the end products of the industry, four reactions are mainly employed:

1) *Hydrogenation.* The complete or partial hydrogenation of an unstable resin. A good example of this is the development of a surgical tape that will not harden after processing.

2) *Esterification and hydrogenation.* These two reactions are used extensively in the paint and varnish processes.

3) *Disproportionation.* This reaction, when applied to resin acids, is capable of producing a sodium soap and a catalyst for the butadiene-rubber industry.

4) *Combination reactions.* As applied to resin acids, a multitude of intermediate and end products can be obtained by the proper selection of the desired reactions.

Terpenes

Also produced in the naval stores industry are terpenes. These are a valuable and versatile group of organic compounds. They are end products of the distillation step in the gum rosin and wood rosin (aged stumps) processes. Terpenes are classified as acyclic, monocyclic, bicyclic, and tricyclic. The monocyclic terpenes are used as rubber solvents in industry. Bicyclic terpenes are used as a basic ingredient for the manufacture of insecticides and synthetic pine oil. Terpenes are processed using disproportionation, dehydrogenation, hydrogenation, halogenation and oxidation, or a combination of these reactions.

Perhaps the most difficult problem to assess in the industry is the actual supply of raw material stumps. In answer to a question on this subject, Tyler stated that when asked the same question 25 years ago, the industry said it had a 25-year supply on hand, and when asked today it still has a 25-year supply on hand.

AMONG MOST ACTIVE SECTIONS, SOUTHERN CALIFORNIA REPORTS THREE SUMMER MEETINGS

The Southern California Section (R. D. Sheeline) has made an enviable record of holding section meetings—and of reporting on them to CEP.

In June the section heard F. L. Hartley, vice-president for research at Union Oil Co. of California, analyze research in the oil industry. Hartley, a past chairman of the section, compared research expenditures of various industries in the U. S. and pointed out that nearly $200 million a year is spent by the oil industry. While this is a significant fraction of the total $6 billion spent annually, other industries spend significantly more. For example, $915 million was spent by the aircraft industry on research in 1955, and $823 million by the electronics industry.

Union Oil itself is noted for a particularly extensive research program (2½ per cent of gross income compared to 0.8 per cent for the average of the industry), and its operations have been watched with strong interest. Union spends 50 per cent of its research budget on refining and manufacturing studies, 21 per cent on exploratory and production problems, 15 per cent on developing new petrochemicals, the rest on miscellaneous items such as corrosion.

Production improvement is being accomplished in several ways. Water flooding is one. Other methods are to pump gas back into the ground to increase the pressure energy, solvent flooding with propane and butane to decrease viscosity, and controlled underground fires to lower viscosity by heating and to provide additional pressure drive from the gases formed as a result of the combustion.

Perhaps most-watched of Union's projects is the oil shale project in the Piceance Creek basin in northwest Colorado. Here a strip mining operation followed by crushing and retorting produces 8° API tar very similar to an 8° API oil obtained from nearby wells. A recent U. S. Geological Survey estimated that the Piceance Creek oil shale basin contains about one trillion barrels of oil. For comparison, the American Petroleum Institute's estimate of proved crude oil reserves in the U. S. is 33 billion barrels.

A record 182 members turned out for the section's July meeting which was a visit to the new Torrance Plant of Union Carbide Chemical Co. Main products shown to the members—polyethylene and ethylene glycol. Newest of Carbide Chemical's seven plants, production is 5 million gallons a year of ethylene glycol and 60 million pounds a year of polyethylene pellets. At the plant the incoming refinery gases are treated to remove sulfur, thermally cracked, fractionated in columns, and the ethylene fraction is solidified at a pressure of 25,000 lbs./sq.in. For ethylene glycol manufacture, the ethylene is combined with air to form ethylene oxide and then hydrogenated to form the glycol. Polyethylene at Torrance is tailor-made for particular uses. Particular attention is paid to the problems of giving the customer what he wants.

(*Continued on page* 120)

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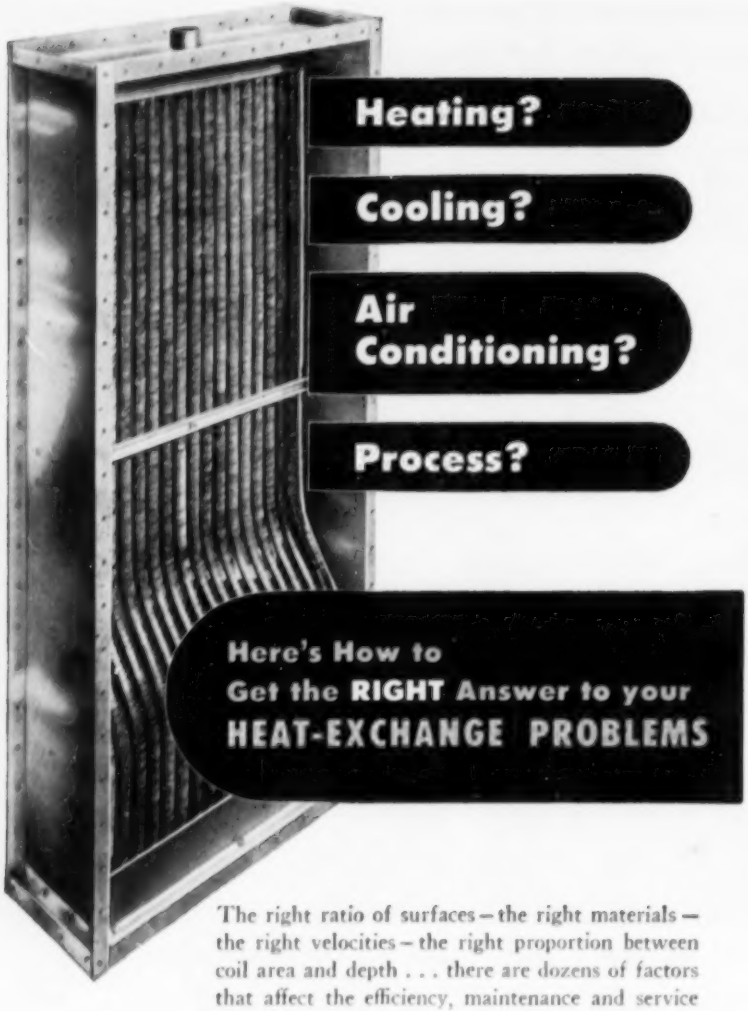

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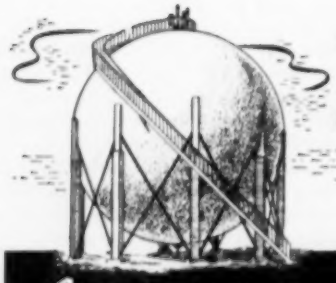

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News of the Field
FROM LOCAL SECTIONS

(*Continued from page* 118)

The Economics of Decision Making was the provocative subject at the **Southern California Section's** August meeting. Four panelists led the way: H. F. Wiley, Consolidated Eng.'g, R. W. Buttrey, tax consultant, P. F. Leuth, Union Oil, and F. W. Winn, Fractionation Research, Inc. The men are all "market researchers."

Wiley pointed out that market research, the "scientific" gathering, reporting and analyzing of all transactions from production to final sale, helped management avoid decisions based on authoritarianism, historical precedence, or intuition. While market research is not a substitute for a sound and experienced management, it provides management with an excellent tool if due recognition is given to the hazard of improper or unsound analysis of the statistical results.

How taxes influence business policy was explained by Buttrey. One example showed that it is sometimes better to divide a company into several corporations. If earnings exceed $25,000 a year, profits are taxed at 52 per cent, while profits below $25,000 a year are taxed at only 30 per cent. Three corporations, each earning $25,000 a year, would be taxed less than a single corporation earning $75,000.

There are two types of capital expenditure, according to Leuth: working capital and expense money for raw materials and operating costs. The first is a long-term obligation and lasts until the assets wear out, and average rate of return can be easily estimated for it. But expense money is used up quickly. In order to get the most profitable return possible, it is necessary to make an estimate of the expected profit and the total capital required, then to determine a relationship between these two items.

The effect of the risk factor in decision-making was Winn's concern. Certain risks can be covered with insurance, others, such as success or failure of a project, cannot. In assessing risk, care must be taken to make a proper analysis and not to be influenced by what seems to be a very high risk potential. High as the possibility of failure may be, the return for success can be so high as to offset this. Wildcat oil wells are dry in 80 per cent of the cases—but when one does come in, the earning rate is so high it offsets the previous 80 per cent failure and much more.

(*Continued on page* 125)

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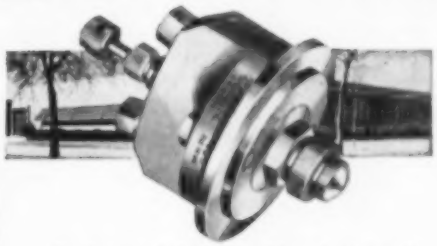

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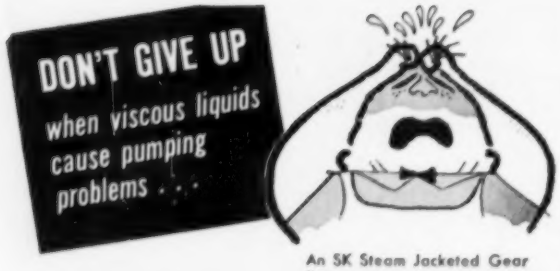

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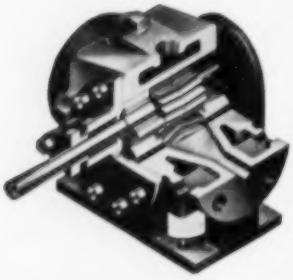

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Rotameters & Flow Indicators: Ask for Condensed Bulletin 18-A2.
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Heat Transfer Apparatus: Ask for Condensed Bulletin HT-1.
Gear Pumps: Ask for Bulletin 17-A.

gilco

DRUM RECONDITIONING MACHINES

keep your drums making more trips

GILCO Model VSDD-56, Vacuum Syphon Drum Dryer removes residue rinse water and dries drums in one operation. Suitable for any size end or side filler drums. Machine is a complete unit and available for from two to fifteen drum stations.

There's a GILCO machine for every phase of steel drum reconditioning. For complete details and specifications on the equipment to solve your particular problem, write DEPT. VD.

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CANDIDATES FOR MEMBERSHIP IN A. I. Ch. E.

The following is a list of candidates for the designated grades of membership in A.I.Ch.E. recommended for election by the Committee on Admissions.

These names are listed in accordance with Article III, Section 8 of the Constitution of A.I.Ch.E.

Objections to the election of any of these candidates from Members and Associate Members will receive careful consideration if received before November 15, 1957, at the office of the Secretary, A.I.Ch.E., 25 West 45th Street, New York 36, N. Y.

Member

Adam, George E., *Trona, Calif.*
Arnett, D. H., *Dhahran, Saudi Arabia*
Bates, Robert L., *Dayton, Ohio*
Bienstock, Daniel, *Pittsburgh, Pa.*
Bower, John R., Jr., *Idaho Falls, Idaho*
Brown, Amon H., *Albany, Calif.*
Burns, Bruce, *St. Albans, W. Va.*
Chunga, Joseph R., *No. Wilbraham, Mass.*
Dean, George W., III, *Chester, Va.*
Dorn, Herman W., *Decatur, Ill.*
Duffey, Dick, *College Park, Md.*
Ellis, William W., *Columbus, Ohio*
Fochtman, Edward G., *Elmhurst, Ill.*
Goodman, A. C., *Los Angeles, Calif.*
Goodman, Eli I., *Pittsburgh, Pa.*
Harrison, Roy C., *Bartlesville, Okla.*
Haun, James W., *Minneapolis, Minn.*
Heger, Edward N., *Menominee, Mich.*
Hinchliffe, B., W. *Pittsburgh, Pa.*
Houston, Reagan, *Buffalo, N. Y.*
Kintner, Robert C., *Chicago, Ill.*
Klemgard, E. N., *Pullman, Wash.*
Kolins, Jack T., *Denver City, Texas*
Lieberman, Alvin, *Skokie, Ill.*
Matzner, Otto R., *Louisville, Ky.*
McLaren, George W., Jr., *New Brunswick, N. J.*
Morgan, Arthur I., Jr., *Albany, Calif.*
Napoli, N. Paul, *Newark, N. J.*
Paulson, William T., *Kenmore, N. Y.*
Pollock, Warren N., *Clearfield, Pa.*
Raynes, Selden H., *Richmond, Va.*
Reber, Elwood J., *Schenectady, N. Y.*
Sanderson, Charles F., *Dallas, Texas*
Scheiber, Robert E., *Naugatuck, Conn.*
Scott, J. W., *Richmond, Calif.*
Siefen, Howard T., *Pasadena, Texas*
Tait, Murray M., *Kankakee, Ill.*
Thiele, Alfred W., *St. Louis, Mo.*
Thornton, Harold A., *Conshohocken, Pa.*
A. Tirado A., *Tlalpan, Mexico*
Trepanier, Norman W., *Detroit, Mich.*
Veltman, Preston L., *Baltimore, Md.*

Associate Member

Aitala, Roger, *Syracuse, N. Y.*
Alazraqui, E. J., *Buenos Aires, Argentina*
Albright, Charles F., *W. Covina, Calif.*
Alessandro, Louis P., *Brooklyn, N. Y.*
Alexis, Robert, *Falconer, N. Y.*
Ammann, Paul R., *Boston, Mass.*
Anderson, Richard, *Milwaukee, Wis.*
Anderson, Ronald L., *Pasadena, Texas*
Antal, William, *Irvington, N. J.*
Bakhshi, N. N., *New York, N. Y.*
Baldwin, John E., *Ridgecrest, Calif.*
Baranano-Perera, Carlos, *Detroit, Mich.*
Barnes, George R, *Oak Ridge, Tenn.*
Barnett, Stanley, *Brooklyn, N. Y.*
Barry, Henry M., *New York, N. Y.*
Bartholomew, Edward L., *Bayside, Va.*
Bartlett, John W., *Schenectady, N. Y.*
Barton, H. Dudley, *Solon, Ohio*
Becker, P. Carey, *New Orleans, La.*
Bergstrom, Bert, *Milwaukee, Wis.*
Bernard, William L., *St. Louis, Mo.*
Bertelsman, Dale M., *Orange, Texas*
Bookmyer, Gerald R., *Clyde, Ohio*
Bourus, G. J., *Alexandria, Va.*
Bracy, Frank L., Jr., *Broad Brook, Conn.*
Brasfield, Earl N., *La Marque, Texas*
Brau, Herminio M., *Roosevelt Station, Puerto Rico*
Brooks, Jonathan O., *Terre Haute, Ind.*
Brosilow, Coleman B., *Philadelphia, Pa.*
Bruce, Robert S., *Ballinger, Texas*
Buckingham, Paul A., *Los Angeles, Calif.*
Burbank, Dewey A., *Oak Ridge, Tenn.*
Byrne, Henry S., *Omaha, Nebraska*
Carruthers, Elizabeth Ann, *Cutchogue, N. Y.*
Cary, William F., *Tulsa, Oklahoma*
Caverly, Myron R., *N. Augusta, S. C.*
Cerny, Rudolf, *Red Bank, N. J.*
Chapman, Neil E., *Minneapolis, Minnesota*
Chari, N. C. S., *Ann Arbor, Mich.*
Chaty, John Culver, *Metuchen, N. J.*
Cheng, Wayne S., *Ypsilanti, Mich.*
Clarke, James R., III, *Decatur, Ala.*
Cooper, P. Garfield, *Lewiston, N. Y.*
Coursey, Wayne, *Dubuque, Iowa*

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Crespi, Harry G., *Detroit, Mich.*
Crowder, William K., *Bloomingdale, N. J.*
Crozier, David J., Jr., *Brooklyn, N. Y.*
Duke, James O., Jr., *China Lake, Calif.*
Davidson, Clayton L., *Midland, Mich.*
Davis, Kenneth D., *Baton Rouge, La.*
Denison, Gilbert W., *Norman, Okla.*
De Sa, Edward D., *E. Amherst, N. Y.*
Donovan, Alfred J., *Wanamassa, N. J.*
Drajeske, Philip, *Harvey, Illinois*
Dunklee, Albert E., *N. Augusta, S. C.*
Elwell, James H., *Aiken, S. C.*
Fantasia, Augustine John, *Brooklyn, N. Y.*
Fariss, Robert H., *Webster Groves, Mo.*
Farner, Carlos R., *Guatemala, C. A.*
Fauls, Thomas J., *Brooklyn, N. Y.*
Field, Stanley, *Brooklyn, N. Y.*
Fijal, Walter R., *Detroit, Mich.*
Foundos, Albert P., *Bronx, N. Y.*
Frisch, Norman W., *Levittown, Pa.*
Furlong, Ralph D., *Cincinnati, Ohio*
Gale, James V., *Elizabeth, N. J.*
Gardner, Robert Allen, *Rochester, N. Y.*
Gasaway, James W., *Decatur, Ala.*
Glaess, Harvey E., *Forest Park, Ill.*
Glanville, Roger S., *Whittier, Calif.*
Glynn, Eugene F., *Elizabeth, N. J.*
Glynn, James C., *Bronx, N. Y.*
Gold, William, *Midland, Mich.*
Golding, Robert A., *Wilmington, Calif.*
Gravenmier, Jack E., *Charleston, W. Va.*
Green, Raymond C., *Columbia, Tenn.*
Grein, Leo J., *Sequin, Texas*
Gritsko, Raymond Michael, *Nanticoke, Pa.*
Hawley, Phillip W., *Baytown, Texas*
Heard, Peter M., *Skaneateles, N. Y.*
Heidler, John C., *Whiting, Ind.*
Hendelman, Teddy S., *Ft. Worth, Texas*
Henderson, Paul H., *Rochester, N. Y.*
Hoffman, Clair A., *Hatboro, Pa.*
Houser, Henry F., *Gulf Breeze, Fla.*
Hull, J. K., Jr., *Los Angeles, Calif.*
Im, U. K., *Kansas City, Mo.*
Insley, J. Vernon, Jr., *Wilmington, Del.*
Jampole, Alvin, *Laurel, Del.*
Johnson, Alfred L., *Cleveland, Ohio*
Johnson, Lee Murphy, *Lufkin, Texas*
Kaiser, Edward R., *Jr., Norfolk, Va.*
Kastan, K. Hans, *Elmhurst, N. Y.*
Kelly, John M., *Jr., Tulsa, Okla.*
Kemendo, Donald E., *Houston, Texas*
Kenney, Peter J., *Akron, Ohio*

(*Continued on page 124*)

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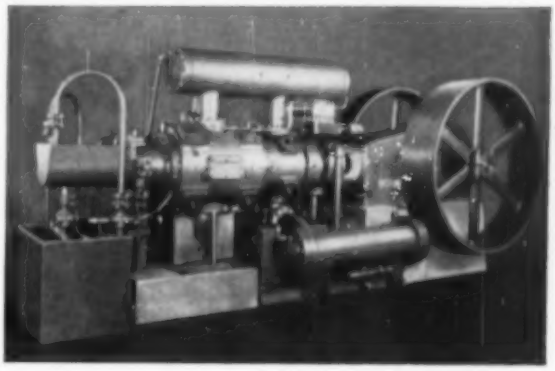
NORWALK

HIGH PRESSURE COMPRESSOR



The five stages on this heavy-duty tandem compressor require less horsepower and develop less heat than in four stages in producing 3000 lb. per square inch pressure in capacities up to 31,000 cfh.

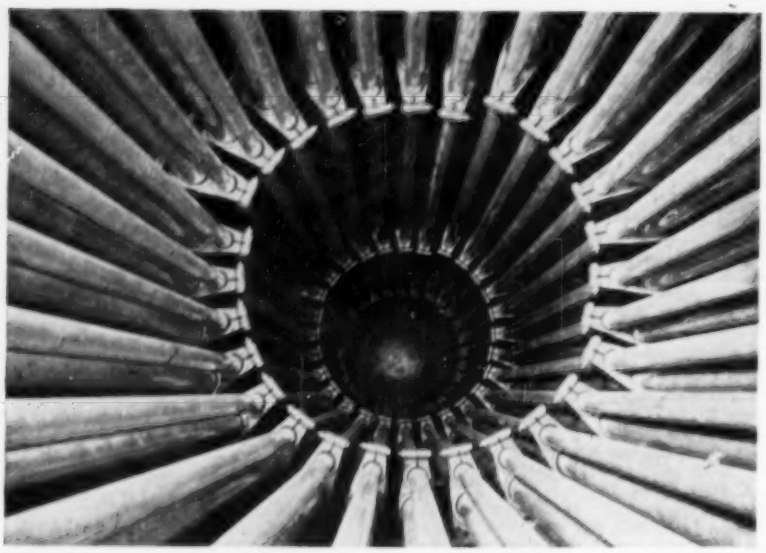
Frames with double row roller bearings, reversible ring plate valves, force feed lubrication, generous intercooler coils are some of the features that make this horizontal compressor compact, sturdy and efficient to operate and maintain.

Every Norwalk compressor is test-run for eight hours at the factory, then taken down for complete inspection before re-assembly and shipment.

Norwalk makes compressors from single stage to six stages, from 125 to 25,000 lb. psi. Catalog on request.

NORWALK COMPANY, INC.
SOUTH NORWALK, CONNECTICUT

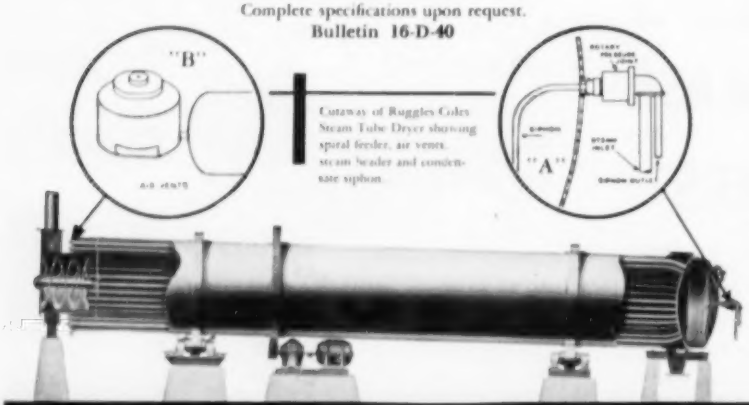
Established 1864



Ruggles-Coles STEAM TUBE DRYERS

- Ruggles-Coles Steam Tube Dryers have been supplied fabricated of aluminum, nickel, monel, inconel, stainless steels and other alloys to provide protection against corrosion and contamination. All fabrication is to code requirements.
- The continuous siphon discharge of condensate is independent of speed of rotation of the shell. (See "A")
- Automatic air vent for each tube eliminates loss of tube heating surface at the feed end of the dryer. (See "B")
- These extra advantages of the Ruggles-Coles Dryer mean continuous maximum output without operating attention and elaborate control devices.

Complete specifications upon request.
Bulletin 16-D-40



Cutaway of Ruggles-Coles Steam Tube Dryer showing spiral feeder, air vents, steam header and condensate siphon.

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(Continued from page 123)

Khatchadourian, Zohrab, *Palisades, N. J.*
Kimball, Philip C., *Bound Brook, N. J.*
Kloostes, Henry Joseph, *Levittown, Pa.*
Knepple, George H., *Brooklyn, N. Y.*
Krebs, William A., Jr., *New York, N. Y.*
Kremer, Fontaine, Jr., *Niagara Falls, N. Y.*
Krieger, Eugene R., *Wyandotte, Mich.*
Kronmiller, R. G., *St. Albans, W. Va.*
Kundrata, Frederick L., *Muskegon Hts., Mich.*
Kurtz, Bruce E., *Syracuse, N. Y.*
Labine, Roland A., *Somers, Conn.*
Lambird, Robert J., *Reno, Nevada*
Landes, Spencer H., *Houston, Texas*
Lash, Leslie D., *Salt Lake City, Utah*
Lawand, Thomas A., *Montreal, Quebec, Canada*
Leavitt, Alfred L., *Medford, Oregon*
Leffler, Walter H., *Tuckahoe, N. Y.*
Leizaola, Pablo, *Caracas, Venezuela, S. A.*
Levis, Ralph H., *Glenside, Pa.*
Lewis, Charles W., *Plainfield, Ill.*
Lewis, Robert E., *Clairton, Pa.*
Linck, Frederick J., Jr., *Denver, Colo.*
Lombard, John F., *Dunbar, W. Va.*
Lynch, Thomas W., *Quincy, Mass.*
Madzin, Donald J., *Clarksburg, W. Va.*
Mahar, John H., *Woodbury, N. J.*
Maier, John Boniface, *Rochester, N. Y.*
Marcheret, John W., *Flushing, N. Y.*
Martin, Robert W., *Terre Haute, Ind.*
Masek, John, *Bellmore, N. Y.*
Mason, J. Lloyd, *St. Louis, Mo.*
Mason, Morris C., *Texas City, Texas*
Master, John E., *Harvey, Ill.*
Mastic, Le Roy L., Jr., *Midland, Mich.*
Mathur, Brijesh B., *Detroit, Mich.*
Maynard, M. J., Jr., *Savannah, Ga.*
McCarter, Lowell H., *Hammond, Ind.*
McDowell, Fred L., Jr., *Reidsville, N. C.*
Mcillvried, Howard G., III, *Alexandria, Va.*
Meier, Marlin D., *Van Nuys, Calif.*
Meller, Michael, *Alexandria, Va.*
Meritt, Arthur D., *Princeton, N. J.*
Moger, William C., *Cincinnati, Ohio*
Moll, Edward J., Jr., *Pitman, N. J.*
Momenthy, Albert M., *Allentown, Pa.*
Mooney, William J., *Aiken, S. C.*
Moore, Donald E., *Coleman, Mich.*
Musick, A. Mack, *Texas City, Texas*
Nance, Blen D., *Northridge, Calif.*
Nation, Robert D., *St. Louis, Mo.*
Niccoli, Lino G., *Redwood City, Calif.*
Norris, Berry E., *Houston, Texas*
Orth, John Carl, *Seattle, Wash.*
Palmer, R. M., *Quebec, Canada*
Patient, William F., *Texas City, Texas*
Paulson, Walter Allen, *Brooklyn, N. Y.*
Pebworth, James T., Jr., *St. Louis, Mo.*
Perna, Angelo J., *Oak Ridge, Tenn.*
Perot, Charles P., Jr., *Middletown, N. J.*
Peters, Richard A., *Lowell, Ind.*
Peverley, Guy D., *Green River, Wyo.*
Pfennig, H. W., *Houston, Texas*
Piper, Mahlon L., *Marshalltown, Iowa*
Polich, William F., *San Lorenzo, Calif.*
Postell, B. V., *Houston, Texas*
Powlow, Raymond R., *Brooklyn, N. Y.*
Qua, Alphonse M., *Manila, Philippines*
Rainey, Don E., *Pasadena, Texas*
Reid, David A., *Naugatuck, Conn.*
Rocheleau, Harold T., *Detroit, Mich.*
Rogstad, Thomas, *George West, Texas*
Rooke, Norbert J., *Berwyn, Ill.*
Samiljan, Ronald A., *Brooklyn, N. Y.*
Schmidt, John P., *Holyoke, Mass.*
Schmidt, Robert G., *Callery, Pa.*
Schorr, Marvin, *Brooklyn, N. Y.*
Schotte, Virgel W., *Kansas City, Kansas*
Seyfrit, Karl V., *Pasco, Washington*
Shane, Robert S., *Pittsburgh, Pa.*
Sherrill, J. C., *Chicago, Ill.*
Shulman, Ronald A., *Linden, N. J.*

News of the Field
FROM LOCAL SECTIONS

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Silveston, Peter L., Linden, N. J.
Smith, Addison M., Williamsville, N. Y.
Smith, Howard B., Bentonville, Ark.
Snow, Larry G., Auburn, Ala.
Sommerville, Ian M., Wayne Country, Mich.
Stanford, Billy W., Florence, Ala.
Sterner, Charles J., Allentown, Pa.
Strickland, H. A., Jr., Aiken, S. C.
Strunk, M. R., East Alton, Illinois
Sullivan, Daniel M., Indian Orchard, Mass.
Topalian, Charles, Long Island, N. Y.
Wann, Dean L., Midland, Mich.
Watjen, John W., Wayne, N. J.
Weitzel, Donald F., Sepulveda, Calif.
White, Clement, Chicago, Ill.
Whitlock, Malcolm, Media, Pa.
Williams, Thomas A., Bay Village, Ohio
Williamson, John F., St. Albans, W. Va.
Willis, James L., Dardanelle, Ark.
Wilson, Dennis C., Chicago, Ill.
Wood, Russell A., Farmington, Mich.
Wurst, Perry E., III, Buffalo, N. Y.
Ziemba, Gerald P., Newark, N. J.
Ziemba, Walter J., Newark, N. J.

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- No internal lubrication . . . air is free of oil vapors or moisture.
- High volumetric efficiency maintained with negligible slippage and with constant volumes delivered regardless of pressure.
- Impellers make no internal contact keeping friction loss small.
- Higher operating speeds result in reduced first cost, less weight and floor space. Horsepower is determined by operating pressure, resulting in maximum power savings.
- Drives may be direct-connected to electric motors, turbines, steam or gas engines . . . or speed reducing gears or V-belts.

In chemical, waste treatment, refining, paper and many other industries, R-C blowers have earned outstanding acceptance. R-C application engineers will welcome the opportunity to help solve your problem, large or small. Write for Bulletins AF-154 on small blowers or RB-154 on large units.

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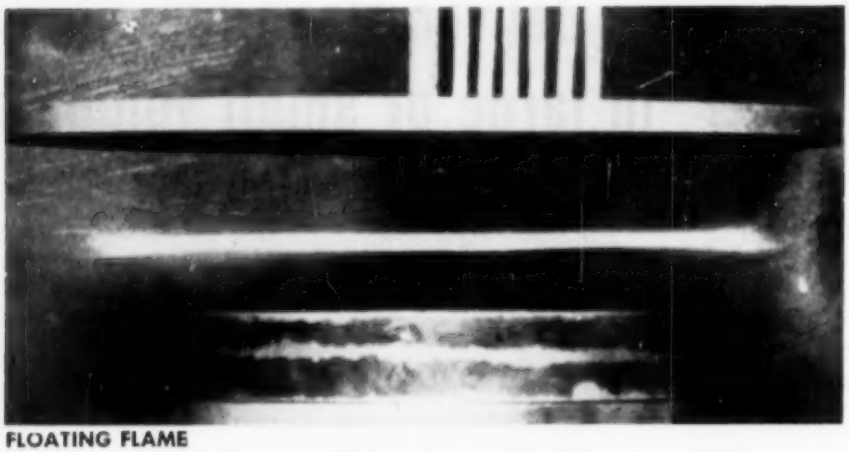
CEP CAMERA

FIRE BRICK MELTS AWAY

Arc image furnace produces temperatures high enough to melt fire brick, announces the research laboratories of National Carbon Corporation. Producing temperatures above 7,000° F., the highly polished mirrors receive their thermal energy from conventional motion picture projection equipment. Only materials capable of absorbing the radiant energy of the beam can be heated—a reflective rather than absorptive material would remain relatively cool, while a black body would become extremely hot.

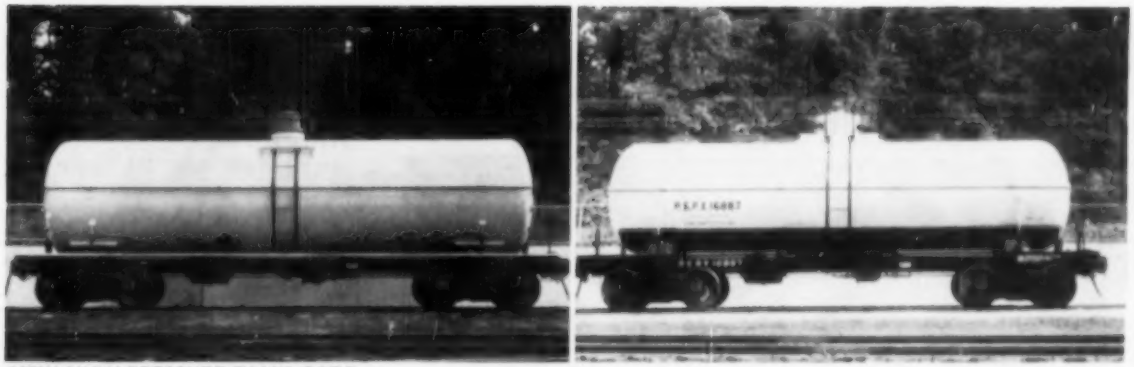


FLOATING FLAME

A flat, floating flame—a pancake-shaped disc of fire which burns while floating free of contact from any surface—has been produced by technologists at Johns Hopkins University. The apparatus is simple, explanation more difficult. Gas is emitted from tube, ignited, and flame hovers between the tube opening and a circular copper plate. "Why it works is still a mystery," said the project director. Flame was developed by Hopkins chemical engineers working for two years on an Air Force project to study effect of spraying a liquid fuel into the combustion chamber of jet-type aircraft. This simple flame provides a controlled combustion reaction, eliminating complex variants.

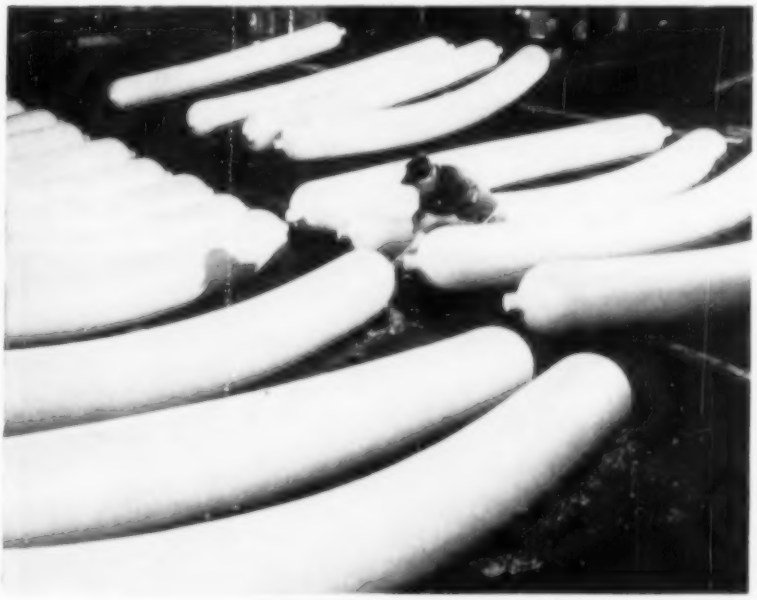
OSU'S NEW BUILDING

Ohio State University's proposed new chemical engineering building is designed to accommodate twice the present student capacity of about 200. Plans approved last month call for 37 laboratories, will entail an expenditure of $2,400,000, embody 973,000 cu.ft. of space. A process development lab. will be part of the unit operations lab. Included in the building will be metallurgical, petroleum, and nuclear engineering facilities which are under chemical engineering.



NEW HIGH-PRESSURE TANK CARS

are making their first U. S. appearance, are designed to eliminate need for insulation, will handle LPG and anhydrous ammonia. Design pressure is 400, rather than the conventional 300 lb./sq.in. A development of Advanced Products Division of ACF Industries, the white cars have an internal temperature on sunny days said to be about 10° lower than conventional black cars.

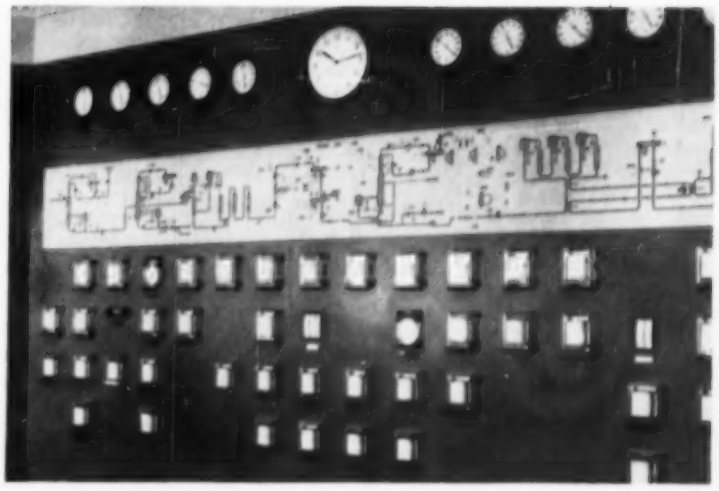


10,000 LB./SQ.IN. FRANKFURTERS

What appear to be frankfurters on a giant griddle are in reality space-saving 15-ft., 10,000 lb./sq.in. oxygen storage cylinders for submarine installations. Such cylinders (including straight sided vessels) are being produced by U. S. Steel Corp.'s Christy Park plant of the National Tube Division from white hot billets which are pierced into a hollow forging under pressure.

LATEST IN GRAPHIC PANELS

is shown at American Gilsonite Company's new refinery near Grand Junction, Colo. Designed by engineering staff of Standard Oil Co. (Calif.), one of parent organizations, panel represents divergence from straight flow-diagram design. Instead, a more comprehensive flow diagram is keyed to the instruments below by symbols, is said to give operators considerably more information about the signals displayed on the instrument panel.



people

JAPAN SOCIETY OF AUTOMATIC CONTROL HONORS BOYD

David M. Boyd, head of Universal Oil Co.'s instrument department, was guest of honor and principal speaker at the April, 1957, anniversary celebration of the Japan Society of Automatic Control in Tokyo. Boyd presented a scroll from the American Institute of Chemical Engineers to Kankuro Kanshige, president of the Japan Society of Automatic Control. During his visit to Japan, Boyd visited all petroleum refineries in Japan which license Universal Oil Co. processes, among them the new plant of Idemitsu Kosan Co. at Tokuyama which was dedicated on May 29. Boyd found in Japan a serious shortage of trained chemical engineers and a distinct lack of liaison between industry and the academic world.

James H. Curtis, formerly vice-president in charge of engineering and construction of the Lummus Co., has been elected president and chief executive officer of Chemical Construction Corp. Curtis was also elected a director of the corporation.

Curtis

New members of the staff at the Whiting Research Laboratories of the Standard Oil Co. (Indiana) include **Ralph G. Zelmer, Burton E. Toepp, 2nd, George M. Longland, Jr., Rodney W. Dunlap,** and **Theodore D. Ahlgren.**

Thomas P. Simpson, vice-president and director of manufacturing for General Petroleum Corp., moves to New York, where he will become general manager of manufacturing of Socony Mobil Oil Co. He will be succeeded as vice-president and director of manufacturing at General Petroleum by **Richard E. Lauterbach,** formerly manager of General Petroleum's Manufacturing Department.

Simpson

Lauterbach

Western Phosphates, Inc. announces appointment of **George H. Reid** as plant manager at their Garfield, Utah, plant. Before joining Western Phosphates in 1953, Reid was associated with Stauffer Chemical Co.

Mead Johnson & Co., Research Division, names **Edwin H. Vause** as director of laboratory administration. Vause comes to Mead Johnson after nine years with Standard Oil of Indiana at its Whiting facility.

Vause

Three new department heads have been named by Shell Development Company's Development Division: **Edward Gelus** to head the Oil Reaction Process Dept.; **George E. Liedholm** to head the Oil Process Engineering Dept.; and **Gino J. Pierotti** to be chief of the Chemical Separation Dept. The assignments form part of a reorganization program to separate oil process development from chemical process development.

Newly-appointed senior chemical engineer for process design at General Tire & Rubber Co. is **Howard R. Wilson.** Wilson was previously staff engineer with the H. K. Ferguson Co., Cleveland, Ohio.

R. S. Manne promoted to senior chemical engineer in the Research and Development Division of Humble Oil & Refining's Baytown, Texas, refinery.

Harry F. Poll, formerly process engineering supervisor for Union Oil of California, joins Ehrhart & Associates, Inc., Los Angeles and San Francisco, Calif., as process development manager.

Union Carbide has appointed **Charles H. Atwood** president of their subsidiary, Union Carbide Caribe. Union Carbide Caribe will operate the new petrochemicals plant under construction near Ponce, Puerto Rico, which will produce ethylene oxide and derivatives.

As of November 1, 1957, **Walter F. Lobo,** presently director of the Chemical Engineering Division of M. W. Kellogg, will be associated with the firm of Devys and Lobo, consulting chemical engineers, in New York City. Long active in A.I.Ch.E. affairs, Lobo is a candidate for A.I.Ch.E. vice-president in the coming Fall 1957 elections.

Lobo

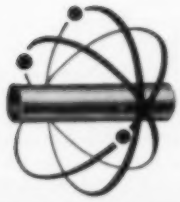
L. C. Kemp, Jr., formerly general manager of the Texas Co.'s Petrochemical Dept., has been named vice-president in charge of that department. Kemp will be responsible for the company's interests in the field of petrochemicals.

George F. Jenkins assumes post as staff assistant, chemicals and plastics, at Union Carbide International Co. In his new capacity, Jenkins will develop economic evaluations of projects and will assist in the planning and coordinating of the activities of the Chemicals and Plastics Division.

Jenkins

Newly-appointed manager of resin and fluid operations in the manufacturing section of the Silicone Products Department, General Electric Co., Waterford, N. Y., is **Reuben Gutoff.** In his new position, Gutoff will be responsible for production of silicone resins, fluids, emulsions, and specialty products. Also at General Electric, **J. L. Galt** will be West Coast general manager for the company's Chemical Materials Department.

(*Continued on page* 130)



About the

NUCLEAR PRODUCTS DIVISION OF SUPERIOR TUBE

For design and construction of intricate reactor components of special types

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This division offers the atomic industry the teamwork of a wide variety of highly skilled personnel, including mechanical, metallurgical and welding engineers, fully qualified to assist in developing Classified and commercial projects. They are supported by expert inspectors and quality control people who insure close adherence to all specifications.

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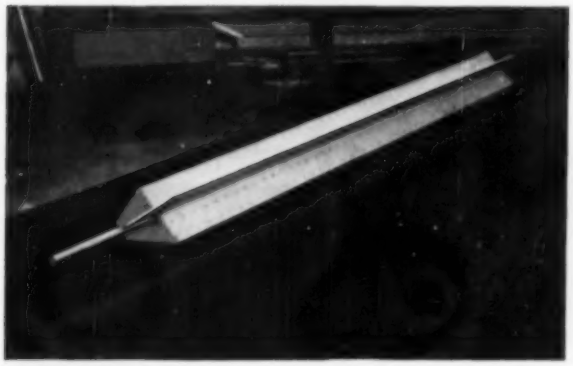

KNOW-HOW

Among the many products being turned out by this division are specially shaped control rod channels, assembly channels, and control rods; also reactor components produced from sheet, bar and plate in squares, hexagons, rectangles or rhombuses, all produced to very close tolerances. The Nuclear Products Division is currently serving many of the key manufacturers in the atomic energy field.

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These include help in the design of reactor components; design and construction of intricate tools and fixtures to fabricate reactor components; development of manufacturing facilities after the prototype has been fabricated. Many materials are utilized, including the reactive metals—titanium, zirconium and their alloys. We also supply tubing for many atomic applications.

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Write for Bulletin 23 —V.

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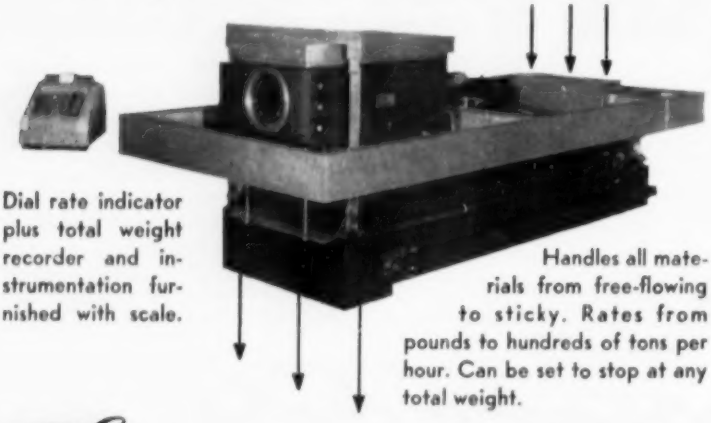

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people

Robert L. Purvin will become executive vice-president of the Foster Grant Co., Leominster, Mass. To accept the newly-created position with Foster Grant, Purvin resigned as president and director of Purvin & Gertz, Inc., consulting engineers of Dallas, Texas.

Purvin

R. S. Abrams becomes general manager of the Silicones Division, Union Carbide Corp. Abrams joined Union Carbide in 1941 when he went to work for Linde Air Products Co.

Joseph M. Smith, dean of the College of Technology, University of New Hampshire, appointed professor and chairman of the Department of Chemical Engineering at Northwestern University Technological Institute.

Howard J. Morgens has been elected president of the Procter & Gamble Co. He succeeds **Neil McElroy,** whose appointment as Secretary of Defense was confirmed by the United States Senate in August.

Morgens

the chemical engineer in MARKETING

A. K. Hoge will be special representative for the Boston office, Chemical Division, Goodyear Tire and Rubber Co. Hoge will service rubber and plastic processing companies in the New England area.

Buflovak Equipment Division, Blaw-Knox, appoints **James V. Roy, Jr.,** as senior sales engineer for its line of chemical and food processing equipment in New York City and vicinity. Roy was formerly project engineer with Singmaster & Breyer, consulting engineers of New York.

Malcolm M. Renfrew, research director of Spencer Kellogg and Sons, Inc., Buffalo, N. Y., named chairman-elect of the American Chemical Society's Chemical Marketing and Economics Division. Renfrew will also be 1958 chairman of the Organic Chemists Club of Western New York.

The Marston Medal, given annually by Iowa State College to an outstanding engineering alumnus, goes in 1957 to **Ronald J. Rockwell,** vice-president and director of engineering, Crosley Broadcasting Corp.

Barrett Division, Allied Chemical & Dye, announces choice of **Robert Q. Hunter** as superintendent of their coating resins plant in Toledo, Ohio.

Among recent chemical engineering graduates who have joined the technical staff at the Whiting plant of Union Carbide Chemicals are **Richard L. Floyd, James W. Givens,** and **John H. Woodruff.**

William W. Cooper, professor of industrial administration and economics at Carnegie Institute of Technology, has been appointed the first Ford Distinguished Research Professor in the Graduate School of Industrial Administration at Carnegie. The Distinguished Professorship was established last spring by a Ford Foundation grant of $500,000.

A $22,000 grant from the National Science Foundation goes to **Robert C. Kintner,** professor of chemical engineering at Illinois Institute of Technology, to enable him to continue his study of the motion of moving bubbles and drops. Kintner, a staff member of the Institute since 1937, is chairman of the Chemical Engineering Education Projects Committee of A.I.Ch.E.

National Carbon Co. appoints **William W. Palmquist** as chemical products marketing manager. Palmquist will be responsible for the complete line of carbon and graphite products supplied by the company to the chemical processing and allied industries.

Palmquist

Also at National Carbon, **C. E. Ford** becomes new products marketing manager, responsible for developing industrial markets for products coming out of the company's research and development laboratories.

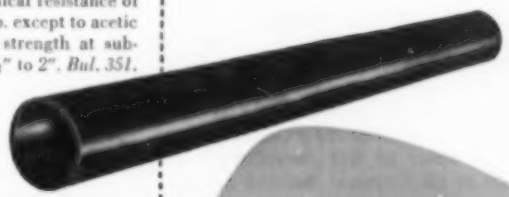
Ford

Ralph R. Calaceto named manager and sales engineer of the Process Equipment Division of Automotive Rubber Co. of Detroit. Calaceto, who comes to the company after more than six years as project engineer with Chemical Construction Corp., will work out of the company's New York offices.

(Continued on page 132)

STAYS TOUGH AT SUB-ZERO TEMPERATURES

ACE PARIAN . . . odorless, tasteless, rigid polyethylene. Best chemical resistance of any plastic at room temp. except to acetic acid. Excellent impact strength at sub-zero temp. Rigid pipe ½" to 2". *Bul. 351.*



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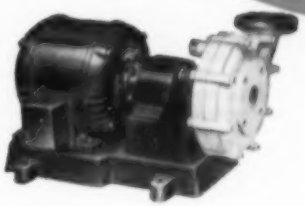
Eleven job-proved rubber and plastic materials now available in ACE piping, valves, pumps and tanks. Tough Ace-lite rubber-plastic blend . . . Saran . . . heat-resistant Tempren . . . Rivicor PVC . . . many others. Write for comparative properties Bulletin CE-50 . . . or call your American Hard Rubber Company distributor.



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the chemical engineer in

MARKETING

Whiting Corp. has transferred **John F. Tourtellotte,** process engineer with their Swenson Evaporator division, to Whiting's district sales office at Detroit, where he will specialize in the sale of all Swenson chemical processing equipment. Tourtellotte was co-author of a paper on "Heat Transfer in Spray Dryers" presented at the recent A.I.Ch.E. National Meeting in Baltimore.

Donald K. Ballman, since 1949 general sales manager of Dow Chemical, has been promoted to the post of director of sales. At the same time, Dow announces promotion of **William R. Dixon** to succeed Ballman as general sales manager.

Ballman

Roger Williams, Jr., president of Roger Williams Technical & Economic Services, Inc., has left for Europe where he will address the Thirtieth International Congress of the Societe de Chimie Industrielle at Athens, Greece, on the subject "Chemical Market Research in North and South America."

Michael J. Cram has joined the Engineering Sales Group of Monsanto Chemical's Inorganic Chemicals Division at St. Louis. Also at Monsanto, **James B. Irwin** has been appointed manager of petroleum sales for Monsanto's Lion Oil Company Division at El Dorado, Ark.

Robert M. Morgan, formerly with Du Pont in Wilmington, Del., named field representative of U. S. Gasket Co., Plastics Division of the Garlock Packing Co., Palmyra, N. Y. Morgan will cover the area under the jurisdiction of the Chicago and St. Louis branches.

Robert Kirk has joined Amoco Chemicals Corp. as manager for international sales of the company's products including petroleum additives, solvents, hydrocarbon resins, plasticizers, and chemical intermediates. Kirk was formerly manager of the Foreign Division of Pittsburgh Coke and Chemicals and president of Pittsburgh Chemicals Mexicana, S. A.

Kirk

Necrology

Irving Langmuir, *76,* 1932 winner of the Nobel Prize in chemistry. Langmuir was on the staff of the General Electric Research Laboratory from 1909 until his retirement in 1950.

Harold R. Snow, *62,* vice-president of manufacturing and member of the board of directors, American Oil Co. Snow had been associated with Amoco since 1925.

Availability list for

(Also see list in September CEP, p. 158)

1957 NUCLEAR CONGRESS PAPERS

The papers in this list are available in separate copy form until January 15, 1958. Nuclear Engineering and Science Conference papers are priced at 30¢ each. Please order only by paper number; otherwise the order will be returned. Copies of these papers may be obtained from the ASME Order Department, 29 West 39th Street, New York 18, N. Y.

• Plant Containment Concepts & Design

82—Power Reactor Containment Vessels. **90**—Containment for the EBWR. **116**—Design Considerations for an Atomic Power Reactor Containment Structure.

• Protection of Water Supplies

21—Stream Surveys for Radioactive Waste Control. **87**—Radioactive Tracers in the Field of Sanitary Engineering. **88**—Radiochemical Procedures for the Identification of the More Hazardous Nuclides.

• Radiation Processing

86—A Megacurie Cobalt-60 Food Irradiator. **99**—The Nuclear Reactor as an Instrument of Medical Research and Therapy. **114**—Use of Ionizing Radiations in Control of Parasitic Infections. **117**—Basic Concepts in the Application of Ionizing Radiations to Foods for Preservation.

• Reactor Design, Operation, & Maintenance

24—Some Operational Problems of the Nuclear Power Plant. **63**—The Homogeneous Reactor Test Mockup. **66**—Absorber Materials for Reactor Control. **79**—Nuclear Powered Gas Turbines for Light Weight Power Plants. **96**—EBR-11 Control System. **106**—Engineering and Construction of the Engineering Test Reactor. **111**—Stress-Corrosion Cracking Problems in the Homogeneous Reactor Test.

• Shielding, Structural Protection, & Control of Fission Products

17—The Application of Radioisotopes to the Measurement of Soil Moisture Content and Density. **18**—Structural Features of the Waste Disposal System of the Shippingport Atomic Power Station, Shippingport, Pennsylvania. **51**—Materials of Biological Shielding. **107**—Control of Radioactive Material at the Pressurized Water Reactor.

• Waste Disposal

1—Atomic Waste Disposal by Injection into Aquifers. **53**—Separation of Cesium and Strontium from Calcined Metal Oxides as a Process in Disposal of High Level Wastes. **54**—Disposal of Fission Products in Glass. **92**—Problems Facing State Agencies in Handling Treatment and Disposal of Radioactive Wastes.

• Atomic Energy in Industry Conference

Complete transcripts of the entire conference are available at $15 each from the Director, Conference Division, National Industrial Conference Board, 460 Park Ave., New York 22, N. Y.

• Hot Laboratories & Equipment Conference

Bound sets of the papers presented may be purchased at $10 each from ASME Order Department, 29 West 39th Street, New York 18, N. Y.

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CHEMICAL ENGINEER—B.Ch.E. 1947. Ten years' experience technical service, process engineering, cost estimating, plant start-up—chemicals, plastics and petrochemicals. Seeking responsible position in petrochemical production management. Present salary $12,000. Box 5-10.

CHEMICAL ENGINEER — B.Ch.E. 1948. Nine years' experience laboratory, pilot plant, technical service, operations supervision. Considerable experience in plant start-up and process trouble-shooting in production supervision. Cost conscious. Writing ability. Box 6-10.

PROJECT ENGINEER — Thirteen years' plant and equipment design and operation. Now completing $2,000,000 project. M.Ch.E., P.E. Box 7-10.

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PROJECT ENGINEER — B.S.Ch.E., 1938. P.E. Eight years in manufacture of heavy chemicals and explosives. Ten years in chemical plant design and construction. Desire responsible position in design or development. Salary $12,000. Box 9-10.

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CHEMICAL ENGINEER—Eighteen years' experience organic chemicals manufacture, technical and supervision. Aggressive, good personality, mature judgment. Desire permanent management or technical position with advancement potential. Los Angeles area. Box 13-10.

CHEMICAL ENGINEER — M.S. Twenty years' experience petroleum refining, process engineer, development and supervision. Desire position with progressive company. Box 15-10.

(Continued on page 136)

A cast rod of pure uranium,

diffusion coated with silicon to give an impurity gradient,

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At 650° a few fine grains in the center abruptly grow . . .

and continue to grow until a barrier is reached. Single crystals are cut from the rod.

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Advertisements in the Classified Section are payable in advance at 20¢ a word, with a minimum of four lines accepted. Box number counts as two words. Advertisements average about six words a line. Members of the American Institute of Chemical Engineers in good standing are allowed one six-line Situation Wanted insertion (about 36 words) free of charge a year. Members may enter more than one insertion at half rates. Prospective employers and employees in using the Classified Section agree that all communications will be acknowledged; the service is made available on that condition. Answers to advertisements should be addressed to the box number, Classified Section, Chemical Engineering Progress, 25 West 45th Street, New York 36, N. Y. Telephone COlumbus 5-7330. Advertisements for this section should be in the editorial offices the 10th of the month preceding publication.

SITUATIONS WANTED

A.I.Ch.E. Members

(Continued from page 134)

ACADEMIC POSITION—Chemical engineer, Ph.D. Age 39, family. Desire senior staff position in chemical engineering. Teaching, industrial, administrative, and responsible consulting experience. Research-minded. Publications. Appreciate receiving details in first letter and salary available. Box 14-10.

CHEMICAL ENGINEER—B.S.Ch.E., McGill University, 1954, age 25, family. Three and one-half years' supervisory experience with major metallurgical company, in smelting and electrode manufacture. Desire responsible position with wider scope and advancement potential. Box 16-10.

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CHEMICAL ENGINEER—B.S.Ch.E. Case, 1944. Widely varied experience in organic, ammonia, and hydrocarbon synthesis, uranium chemistry. Desire position in process engineering or production. Prefer Gulf Coast or other Southern location. Box 20-10.

Nonmembers

NORWEGIAN CHEMICAL ENGINEER—B.Sc. University of London, England, 1957, Age 28. Desire position in United States, preferably on production side or process design. All Scandinavian languages, English and German spoken. Box 11-10.

CHEMICAL ENGINEER—B.S.Ch.E., 1951. Experience in process studies and engineering connected with utilities and petrochemicals. Also experience in production supervision. Desire process engineering or production work. Box 12-10.

CHEMICAL—MECHANICAL ENGINEER—B.S.Ch.E., 1947, age 36. Ten years' widely varied experience. Desire position with equipment manufacturer which will allow utilization of outstanding mechanical ingenuity. Box 21-10.

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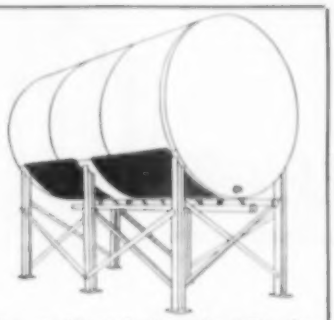

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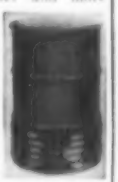

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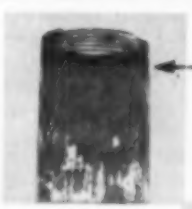

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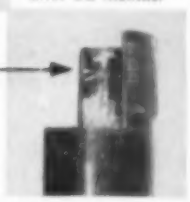

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news and notes of A.I.Ch.E.

Baltimore Meeting in September was the opening of a busy '57-'58 season, which will see its culmination in the Fiftieth Anniversary Celebration in Philadelphia next June 22 through 27 . . . Council began the fall with a meeting at which it heard three significant reports . . .

First of these was a report on what the **Fiftieth Anniversary Celebration** may encompass, by the Chairman of the Fiftieth Anniversary Committee, Past President C. G. Kirkbride, & part of the plans for an international gathering of chemical engineers to celebrate our founding were revealed by him at that time . . . The week-long celebration will include three major luncheons plus a Fiftieth Anniversary Celebration Banquet at which the speaker will be Crawford Greenewalt, President of duPont . . . We expect to have over here a number of foreign guests . . . one of them, Dr. J. A. Oriel, former President of the Institute of Chemical Engineers in London, will speak to us on Wednesday of that week . . . A special award, the Founders' Award, is being planned also & a special committee of Council has been appointed by President Rushton to determine the recipient . . . In addition there probably will be presented to distinguished chemical engineers a series of medallions patterned after the winning sketch in the recent Design Contest & bearing the winning slogan in the Slogan Contest . . . Another committee has been working on this project & the winners will be announced in the November issue of *CEP* . . . Delegates from foreign societies are to be in Philadelphia to help us celebrate this anniversary & we are presently appealing to the Post Office Department for a commemorative stamp to be issued . . . A huge program of public relations is also being planned by the national Public Relations Committee & the local group. . . The festivities of that week are the responsibility of a subcommittee of the Fiftieth Anniversary group headed by Ray Vener of Catalytic Construction & these events will include a kick-off session, an award session, & a convocation where greetings from foreign & domestic societies will be presented to A.I.Ch.E. . . . The technical program is under the direction of Roy Kinckiner of the duPont organization & a full week of outstanding technical sessions is assured . . . All of the local activities are being headed by Bill Chalfont, who has already had more than a year of meetings with the local group planning the local arrangements. In January next year a **plaque commemorating the founding** of the A.I.Ch.E. will be dedicated at the Engineers' Club in Philadelphia & four volumes detailing the history of chemical engineering & A.I.Ch.E. are being worked on now.

Program Committee: Chairman L. J. Coulthurst of Foster Wheeler reported the finishing up of practically two years of planning the reorganization of the Program Committee . . . The new plan, which was approved by Council, provides for the streamlining of the Program Committee to ensure timely topics . . . Plan now calls for eighteen different subareas of program interest & the report outlines an orderly process of arranging for divisions . . . We already have a Nuclear Division . . . the Heat Transfer Division is in the process of being formed . . . & several other areas are being looked at by proponents hoping that sustained interest can be generated so that A.I.Ch.E. may have other areas that will support divisions . . . Divisions have a representative on the Program Committee, but for all intents & purposes are independent in planning their programs. . . . Anyone wishing a full copy of the program plan need only write to Coulthurst.

Warren Schreiner, Chairman of the **Research Committee,** presented the third of the committee reports heard at this Council meeting & this too was outstanding in its promise & importance to A.I.Ch.E. . . . The Research Committee is just finishing the research program in distillation, Plate Efficiencies in Fractionating Columns, & has now obtained Council's permission to enlist support for a research program in vapor-liquid equilibrium . . . Achievement of the research group is a solid one & those who have followed the program carefully will recognize the immediacy of the developments & their importance to companies using distillation.

Guidance Committee this summer got out a news letter edited by T. Peter Forbath & Hugh Guthrie. . . . Several **Student Chapters** were recently created: Colorado School of Mines . . . Mississippi State College . . . Southwestern Louisiana Institute.

Memorial for G. G. Brown has been planned in Ann Arbor Y.M.-Y.W.C.A. . . . a club room bearing his name & financed through the gifts of friends . . . Friends & former students who wish to contribute may send checks to the office of the Dean of Engineering, University of Michigan, Ann Arbor, Michigan . . . George Granger served as a member of the Campaign Committee for the building of the new Y.M.-Y.W.C.A.

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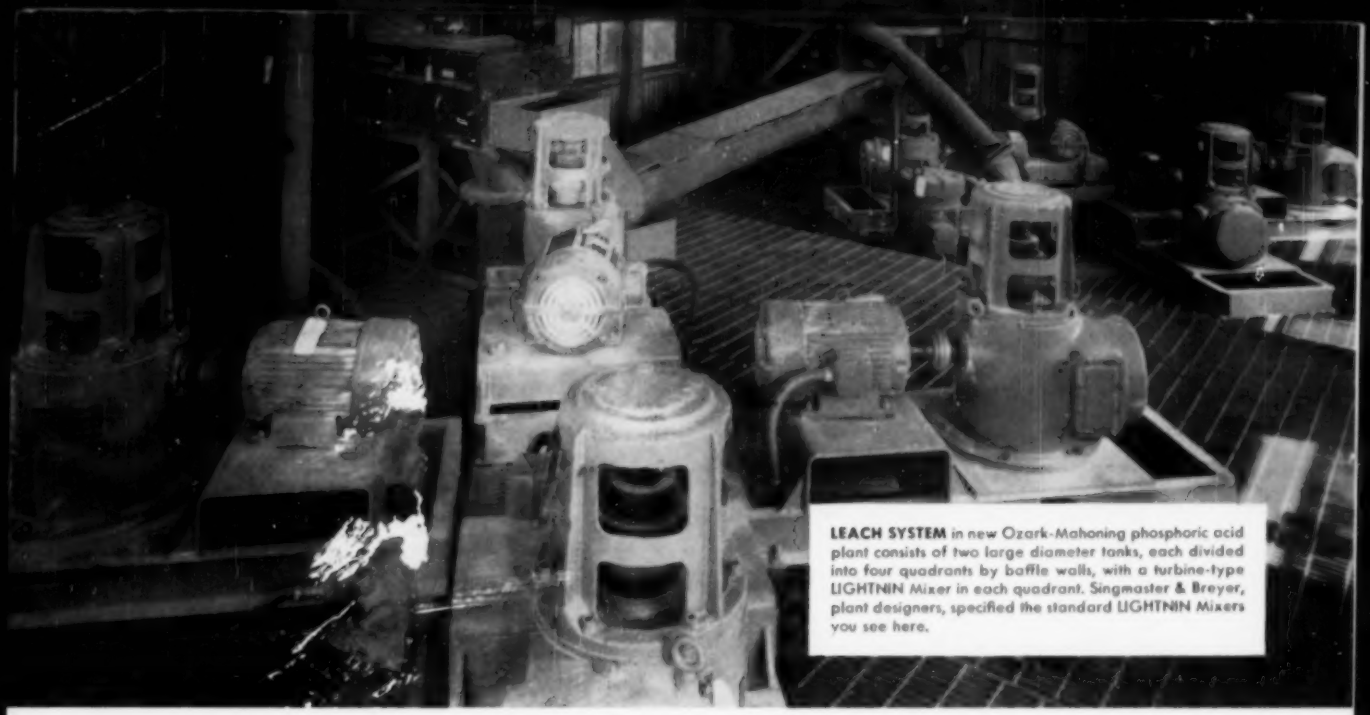

LEACH SYSTEM in new Ozark-Mahoning phosphoric acid plant consists of two large diameter tanks, each divided into four quadrants by baffle walls, with a turbine-type LIGHTNIN Mixer in each quadrant. Singmaster & Breyer, plant designers, specified the standard LIGHTNIN Mixers you see here.

New acid process gives **95% yield** *with good mixing in leach tanks*

More often than you might think, *good mixing of fluids* can make the difference between "just average" and superior process results.

That's one reason why LIGHTNIN Mixers were specified for this new wet-process phosphoric acid plant at Ozark-Mahoning Company, Tulsa, Okla. Singmaster & Breyer, New York engineering firm, did the process and equipment design for Ozark-Mahoning Company.

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Utilizing the Belgian Prayon process, relatively new to this country, the plant consistently yields better than 95% of acid containing 50% P_2O_5. It produces a 52% product from sulfuric acid as weak as 55%.

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The new plant has run without a hitch since the day Ozark-Mahoning operating management pushed the button.

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